Glimpses of Plant Life

Part II

Reading to Learn

Glimpses of Plant Life

Part II

BRIJ MOHAN JOHRI
BHARATI BHATTACHARYYA

Departmental Cooperation
R. D. SHUKLA

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Inset – *Rafflesia arnoldii*, the largest flower
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Background photograph – *Courtesy* , Karan Chadha

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Foreword

THE National Council of Educational Research and Training (NCERT) has been deeply involved in the development of curriculum, textbooks and other related instructional materials at various levels of school education for the last four decades. This has influenced, directly or indirectly, the curriculum and instructional materials of all the States and Union Territories of the country which is a matter of great satisfaction for the Council.

Generally, it is found that despite a good curriculum and textual materials, students rarely get encouraged and motivated towards self-study One of the reasons for this is our examination system, which tests only the knowledge imparted through textbooks Thus, very few students get motivated to read books other than textbooks. Moreover, the reasons for not reading books outside the course can also be attributed to the non-availability of an adequate number of books for different age-groups of children at an affordable price. Although during the last few years, some work has already been initiated in this direction by the Council to overcome this deficiency, it is insufficient.

Taking all these aspects into consideration, the Council initiated an ambitious and innovative project in the form of writing informative and enriching books for children of different age-groups under different themes covering science and technology, languages, literature, social science, biographies, stories, culture, etc. Under this project entitled, *Reading to Learn*, a series of books are being prepared for different age-groups of children in a simple and interesting style in different subject areas by the Council. In the area of science and technology alone, more than thirty-six books have already been developed under this project. We hope that we shall be in a position to publish a large number of books in Hindi and English in new and applied areas of science very soon.

In the development of books in scientific areas, we are seeking the cooperation and help of distinguished scientists, mathematicians d experienced teachers. Each book is given a final shape after eful scrutiny and thorough editing in terms of language, style and bject matter These books are being published at cost price in order nake them accessible and affordable to all children in the country ther, there is also a proposal to get some of these books translated o other Indian languages It is hoped that this project will also be eived well like the other projects of the Council initiated in the ds of curriculum, textbooks and supplementary reading materials.

am thankful to Prof. B.M. Johri and Dr Bharati Bhattacharyya, authors of 'Glimpses of Plant Life', Parts I and II, Prof. R.C. hrotra, distinguished scientist, who is the Chairman of the project, d to Prof. R.D. Shukla, Head, Department of Education in Science d Mathematics for coordinating the project.

Ve will appreciate the comments and suggestions of children, chers and parents for making these books more useful and eficial for the target groups they are meant for.

J.S. RAJPUT
Director
National Council of Educational
Research and Training

w Delhi
e 2001

A Few Words

THIS book is a small effort under the project *Reading to Learn*, of the National Council of Educational Research and Training. I was a little hesitant when Prof. J.S. Rajput, Director, NCERT, requested me to continue with the responsibility of getting science-related books developed under the project. My apprehensions were mainly due to awareness about the hectic schedule of my colleagues from the science community.

It has always been my endeavour to involve eminent intellectuals who have excelled in different disciplines of science and technology in this kind of work. I am of the opinion that only those scientists, who have experienced the thrill of discovery and research, can share their joy of achievement with children. I am grateful indeed to them for sparing some moments from their precious time for the benefit of the youngsters of the country. Children are the treasure of a nation and I am overwhelmed and, at the same time, satisfied, that our distinguished and busy scientists have happily agreed to make some meaningful effort for children. I am grateful to my scientist friends for acquiescing to my request.

In preparing these books, our main objective has been to present the subject matter in a manner that would attract and motivate the children to read. At the same time, the language of the text is simple so that children do not encounter any difficulty in unravelling the mysteries of science while reading these books. I believe that reading these books would inculcate and develop in them the reading habit, arouse their curiosity and encourage them to experiment and satisfy their curiosity.

This project has been given new impetus by Prof. J.S. Rajput, Director, NCERT, for which I am thankful to him.

I am grateful to Prof. Brij Mohan Johri and Dr Bharati Bhattacharyya who accepted my request for writing this book. I am also thankful to Prof. R.D. Shukla, Dean (C) and Head, Department of Education in ence and Mathematics, the coordinator and editor of science books, his sincere and dedicated efforts. Thanks are also due to Shobha Laxmi Sahu for the assistance she has provided in the ject.

hope these books will facilitate development of the scientific nper from early childhood in the coming generations, and create a se of national pride through a knowledge of the latest scientific velopments in our country and glimpses of the endeavours of our entists.

R.C. MEHROTRA
Chairman
Reading to Learn Project (Science)

Preface

In 1978, the late Dr B.P.Pal, former President of the Indian National Science Academy, suggested to one of us (B.M. Johri) to give a lecture on 'Plants' to senior school students. The Academy's auditorium was overflowing and the response was overwhelming.

Due to the interest shown by the students, Dr Pal suggested that I (B. M. Johri) prepare a handy illustrated booklet for the students. Jointly with Dr (Smt.) Sheela Srivastava (then teaching at the Daulat Ram College, University of Delhi; now in the Department of Genetics, University of Delhi, South Campus), the booklet, *Famous Plants,* was prepared. This was published by the Academy in 1978. Later, a Hindi version, *Prasidh Paudhe,* was published by Rajpal & Sons, Kashmere Gate, Delhi.

We have always been interested in anecdotes and episodes connected with plants. So, we decided to prepare this book, 'Glimpses of Plant Life'. It is intended that after the English version in two volumes, the Hindi version will also be published.

Dependence on plants is not a recent happening in human civilization; it started with the appearance of the first man on earth. Today, they provide us with food, fodder, fibres, dyes, drugs, timber, spices, refreshing drinks, perfumes and a host of other commodities. Plants maintain atmospheric balance. Their reckless removal pollutes the atmosphere, causes droughts, floods and famines. Therefore, should we not learn more about plants — the love, hate, romance and the adventures and legends associated with plants and their discovery? It is important to know them, recognize them, name and classify them. It is equally exciting to know the folklores and old legends spun around them. It is certain that some plant commodities used today, were used by man centuries ago in a crude form. For his own benefit, by trial and error, man has learnt the various uses of plants.

'Glimpses of Plant Life', Parts I and II, point out all such details.

e style and presentation are friendly, the information is laced with ecdotes, and references to original work are made wherever the tory is traced. The simple, lucid language used in this book, we pe, will make it appealing to the readers—amateurs, professionals, d even the uninitiated.

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BRIJ MOHAN JOHRI
BHARATI BHATTACHARYYA

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We are grateful to the members of both our families for their peration and moral support during the preparation of the present k.

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He has published about 200 original research papers, reviews and monographs in national and international journals, over 150 additional articles have been published by his students and collaborators He has to his credit eleven books.

Several books have been published by Springer, Heidelberg: *Experimental Embryology of Vascular Plants, Embryology of Angiosperms, Comparative Embryology of Angiosperms* and *Botany in India: History and Progress. The Gymnosperms* (Chhaya Biswas and B.M. Johri, 1997, pp i-xxi+1-494); *Flowering Plants: Taxonomy and Phylogeny* (Bharati Bhattacharyya and B.M. Johri, 1998, pp i-xxi+1-753) and *Reproductive Biology of Plants* (eds. B.M. Johri and P.S. Srivastava, 2000, pp i-ix+1-320) have been published by Narosa Publishing House, New Delhi, in collaboration with Springer, Heidelberg.

Other books under publication are: 'History of Biological Science' (B.M. Johri and Bharati Bhattacharyya) by Allied Publishers, New Delhi. The books under preparation are: 'The Bryophytes', 'The Pteridophytes', 'Dictionary of Archegoniate Plants', and 'Embryology of Angiosperms'.

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Her work emphasized the importance of taxonomic studies as early he 1960s, particularly in the family Leguminosae. Her interests ude ecological studies also. She presented a paper entitled, logical Study of Plant Species Diversity in Delhi Region' at the rnational Congress of Ecology, Yokohama (Japan) in 1990.

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Recently, she has been awarded a grant for a research project itled, 'The effect of environmental changes on some selected baceous plants of Delhi' by the University Grants Commission, v Delhi.

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1

Introduction

The realization that plants are of immense use to humanity, has made them very important to us. Almost in every possible field, be it economic, cultural, political or historical, their influence has been felt from ancient times.

From pre-historic ages till today, the number of useful plants and their uses have increased manifold. As it is interesting to learn about these important plants, it is equally exciting to rummage through the old legends and folklores about them.

Many of these plants have, therefore, turned out to be 'famous'. They are well-known to the layman and the technician alike. Who does not know about Tulsi or Neem?

What makes some of these plants 'famous'? Tulsi or *Ocimum sanctum* (Fig. 2.4) is a plant of worship. From time immemorial it has been associated with Lord Narayana of Indian mythology. In our offerings to the Lord we say "*Tulsi-patranjali*" meaning an 'offering of tulsi leaves'. Its Sanskrit name 'Vrinda' forms the basis of the name of the town Vrindavan, a religious place in North India. Tulsi is also very well known for its medicinal value.

The orchids are famous for their beauty due to the structural variability of their flowers As mentioned by a seventeenth century German botanist, Jacob Breynius, "If nature ever showed her playfulness in the formation of plants it is visible in the most striking way among the orchids". There are Butterfly and Moth Orchids, Dove Orchid, Spider Orchid, and many others. Orchids are the flowers of excellence. It was not until 1731 that the first orchid entered Western collection. Some of these were grown in earthen pots, in compost of rotten wood and decayed leaves. These were plunged into a pit containing tanniniferous substance (Hawkes 1961). It is a wonder that they not only survived but also blossomed!

'Traveller's Tree' is an interesting plant of the Banana family. It is quite similar to a Banana plant in appearance — particularly its leaves. Why is it named so? The leaf bases of this plant, *Ravenala madagascariensis* (Fig. 4.4 A,B), are arranged in such a way that large quantities of rain water collects inbetween them. A thirsty traveller may quench his thirst, by drinking this clear water. By just piercing the base of the leaf-stalk, water flows out.

The Spanish Moss is neither Spanish nor moss, but interesting it is. This rootless epiphyte — *Tillandsia usneoides* — (Fig. 5.2 A,B) hangs in long festoons from trees and sometimes even from telegraph wires and poles — and hence is also called 'Telegraph Plant'.

One of the mysterious plants of the world is the Dragon's Tree or *Dracena draco*. It is so-named because the resin of this plant is blood-red and when the plant is wounded the resin oozes out in drops like human blood.

The Baobab or Bottle Tree, *Adansonia gregorii* from Western Australia, is a tropical curiosity. It is a water-reservoir for thirsty travellers; rain water collects in the bottle-shaped stem.

And then there is the 'Two-leaved Curio' — *Welwitschia mirabilis*

(Fig. 6.3). Despite living for 2000 years, this plant produces only two leaves. It is found in the hot sandy desert of South-West Africa — an area where it may rain only once in five years.

Did you know that the Sandalwood plant — *Santalum album* — a 12 to 13 metres tall tree, is a partial root-parasite and it grows to an age of 60 to 80 years or more? This is a plant which is famous for its fragrant wood and is much sought after by the poor and the rich alike

Rubber from *Hevea braziliensis* has a long history of its appearance in its present state from the time of the Incas of Peru, the Aztecs of Mexico, and the Mayas of Central and South America. The famous ball-game of the Aztecs was played with rubber balls. Other plants of historical importance are cotton (*Gossypium spp.*) and indigo (*Indigofera spp.*). The latter created history during the reign of the East India Company.

The cereals (wheat, rice and maize) are famous as they have led to various ancient civilizations, be it Indian and South-east Asian (rice), or Babylonian, Sumerian and Assyrian (wheat and barley), or the pre-Columbian civilizations of the Mayas, Aztecs and Incas (maize).

Giants and dwarfs of the vegetable kingdom are also famous such as the Giant Red Wood Tree — *Sequoia gigantea,* Giant Water Lily, *Victoria amazonica;* the Big Tree of Tule — *Taxodium mucronatum;* the Pin-heads, *Wolffia microscopica* and many others.

Bonsai are famous because they are naturally and artificially-induced dwarfed plants like Pines, Cypresses, Plums, Bamboos and Oranges, and even Peepal and Banyan tree grown in pots. With some care, these dwarfed plants flower and fruit also. The art of dwarfing large trees and growing them in small pots is an ancient art of Japan and China.

Interesting also are the ancient seeds (of *Nelumbo nucifera*) which germinated after prolonged hibernation in a layer of peat in a naturally-drained lake bed in Manchuria. The estimated age of these seeds is 1,040 ± 210 years (Libby 1951).

All these and many more facets have been discussed.

2

Plants of Worship

Plants and religion are inseparable. It is said that all plants are created from the hair of Brahma, the creator. In India, as in many other countries of the world, trees have been regarded as representing the abode of certain Gods and Goddesses, or the trees themselves have been worshipped as '*Vrikshadevata*' or '*Vanadevata*'.

Bel tree or *Bilva* is sacred in Hindu mythology. The fruits and leaves are essential for worshipping Lord Shiva.

To the Buddhists, the '*Bodhi*' tree or the '*Bo*' tree (Pipal) is the symbol of knowledge because sitting under this tree at Gaya (Bihar, India), Gautama Buddha obtained the 'perfection of wisdom'.

These and some other trees of religious importance are discussed in this chapter.

Banyan Tree

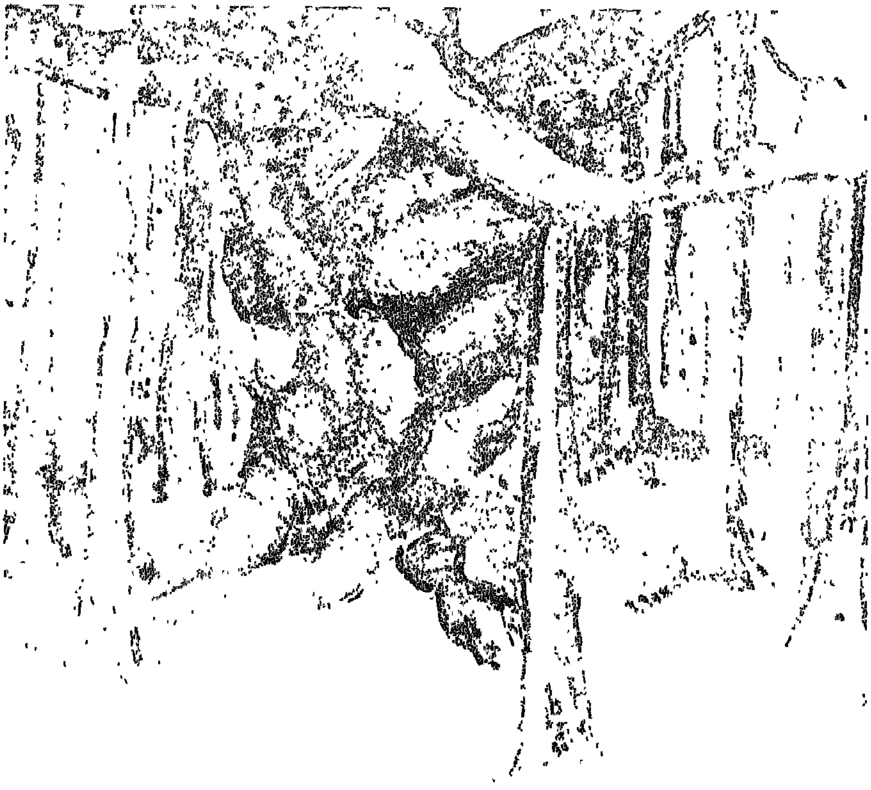
The Banyan tree has been considered as the most wonderful piece of vegetation on this earth. The name 'Banyan' is said to have been given by the British to a tree under which *Banias* or Hindu merchants assembled for business and worship (Gandhi and Singh 1989). The Banyan tree, the holy Ganges and the mighty Himalayas together make the total picture of India.

It is sacred to the Hindus and one usually does not cut it down. Its leaves are sometimes used as fodder. They can also be stitched into platters. Coarse fibres can be made from the bark and the young hanging aerial roots

The tree, according to mythology, symbolizes the three Gods of the Hindu Triad : Vishnu, symbolized by the bark; Brahma, by the roots; and Shiva, by the branches. Kuber, the treasure-keeper of the Gods, is also, known as 'Vatashraya', i.e. one who lives in the Banyan tree

FIG 2 1

Ficus benghalensis, the famous banyan tree of the Indian Botanical Garden, Howrah, West Bengal.



According to another mythological story, Savitri could bring back her dead husband to life by worshipping this tree. On this legend is based the special offering on 'Vat Savitri' day when women fast and worship this tree (Gandhi and Singh 1989).

Banyan trees have also been regarded as symbols of fertility In the '*Hattipala Jataka*' of the Buddhists the story of a woman who was blessed with seven sons by a Banyan tree is narrated.

'Kalpavriksha' of ancient Indian sculpture has been identified as the Banyan tree.

Banyan, *Ficus benghalensis*, is a large, spreading evergreen tree, often reaching up to a height of 100 ft and more, and with numerous hanging aerial roots. To start with, these roots are slender and delicate, and are often protected by enclosing them in split bamboo culms. The entire structure appears like a vaulted canopy. The trunk is never quite cylindrical because it is composed of several amalgamated aerial roots (Venkatesh 1976). From the spreading side-branches hang down clumps of brown aerial roots that eventually unite and on reaching the ground strike root and grow into separate pillars supporting the crown. In very old trees the original main trunk slowly disintegrates and the crown is entirely supported by the trunk-like 'root pillars'. The Great Banyan Tree (Fig. 2.1) of the Indian Botanical Garden at Sibpore, Howrah, is one such example. This is one of the largest trees in the world and is an object of wonder and admiration. It is more than 200 years old and the main trunk which was attacked by fungus was removed in 1925. At that time the girth of the main trunk was 23.49 metres. The tree originally grew on a wild date palm (*Phoenix sylvestris*) before the Garden was established. The total number of aerial roots which have already reached the ground is more than 1,200 and the circumference of its crown is ore than 404 metres. The maximum height attained by one of its anches is about 30 metres. There are many such centuries-old nyan trees in various parts of India.

The leaves are large, leathery, broadly elliptical, dark, glossy-een and conspicuously pale-veined. There are two large stipular ales which cover the leaf-bud (young leaf). As the leaf develops the ales fall off and leave a ring-like scar on the stem. Young leaves en have an attractive reddish hue

Just like other species of *Ficus*, Banyan (*F. benghalensis*) appears have no flowers but only 'fruits'. As a matter of fact, what looks like ruit is a fleshy cuplike structure, with a hollow centre (Fig. 2.2 C, and a narrow opening (ostiole) at the apex. The 'fruit' is a syconium th numerous specialized flowers on its inner fleshy wall. Both male d female flowers (Fig. 2.2 A,D) are contained in the same syconium. male flowers are numerous and cover almost the entire inner rface, whereas the few male flowers are situated at the apical region se to the entrance scales of the ostiole. In each syconium, there ay be 105–113 long-styled or seed flowers, 81–107 short-styled or ll flowers, and 11–19 male flowers. The female flowers mature ahead the male and self-pollination is prevented.

It was long believed that the pollen vector effected pollination ssively by rubbing against the open anthers on its way out of the d syconium, and touching the receptive stigmas on entering the w syconium. It has now been discovered that pollination is not ways as simple as that.

Usually, the number of male flowers is comparatively small and e wasps (pollinators) do not become dusted on their way out. Many the fig wasps [*Ceratosolen arabicus*, pollinator of *Ficus sycomorus*, d *Blastophaga quadraticeps* (Fig. 2.2 F) of *F. religiosa*] have thoracic

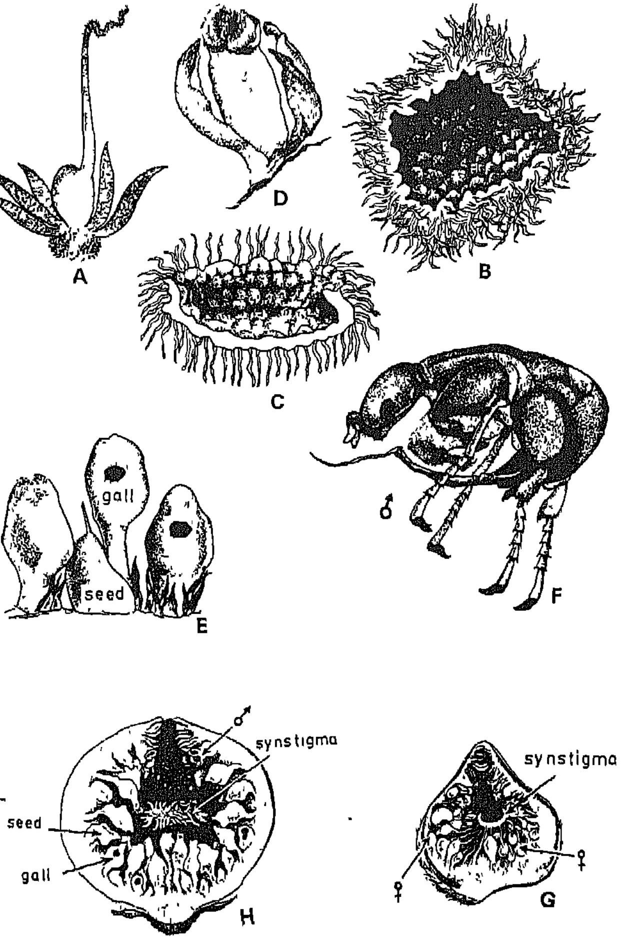


FIG. 2.2 A–H

Ficus sp. *A* Long-styled female flower. *B,C* 'Synstigma', formed by interlacing of the stigma of long-styled flowers. *D* Male flower. *E* Gall and seed flowers; note gall flowers with holes. *F* ***Blastophaga quadraticeps***, the pollinator of *Ficus religiosa*. *G* Syconium—longisectio to show two types of female flowers — long-styled and short-st *H* Same, with seed flowers and gall flowers with a hole an 'synstigma'. Male flowers are near the ostiole.

pollen pockets closed from the outside by a moveable lid. Some other types of wasps have, in addition to open pockets, coxal corbiculae in the form of longitudinal depressions along the coxae (proximal joints) of the forelegs. These also serve to transport pollen. The corbiculae are fringed on one side by a row of long and stiff hairs (comb) which aid in the loading and unloading of pollen.

Before leaving the syconium, the female wasp approaches the anthers and with the help of arolia (lobes or pads) of the forelegs, loads pollen into its pockets which open in response to touch. After entering the receptive syconium, the above movements are repeated in reverse order.

The female flowers in a syconium (Fig. 2.2 H) are of two types: some sessile or almost sessile with a comparatively long style and some pedicelled with short style. The long-curved stigmas (Fig. 2.2 A) are almost at the same distance from the inner wall of the syconium and are interlaced to form a cup-shaped chamber called the 'synstigma' (Fig. 2.2 B,C,G,H). It prevents the wasps within from slipping down between the styles and ovaries. The wasps can bring about pollination only through 'synstigma' and styles. When the 'synstigma' withers away, the way from the ovaries into the cavity of the syconium opens. The wasp now oviposits the short-styled gall flowers. The male wasps escape the gall flowers and fertilize the egg in other gall flowers through a hole (Fig. 2.2 E) in the gall (while the female wasp is still within). The seed flowers and the gall flowers now begin to grow. The endosperm and embryo develop normally in both but, in the gall flowers, the developing female wasp consumes the endosperm and the embryo aborts. As the female wasp matures, it escapes from the gall flower, stretches its body, collects pollen from the now maturing male flowers and then leaves the syconium through the ostiole.

It is to be noted that the male wasps have no role in pollination. The mature anthers attract only the young female wasps. It has been experimentally demonstrated that if a pollen-carrying wasp, with its ovipositor amputated, brings about pollination, normal seeds will be produced (Johri 1989).

Bel (Bilva)

'Bilva' or 'Bel' is considered sacred in Hindu mythology, and it is usually mentioned in connection with Lord Shiva. The fruits and the leaves of this plant are essential for the worship of Lord Shiva. The trifoliate leaves of the tree are supposed to signify the three functions of the Hindu Triad—creation, preservation and destruction.

Many stories have been 'woven' around this tree. It is said that Goddess Lakshmi was a worshipper of Lord Shiva and she used to offer one thousand lotus flowers everyday. One day it so happened that there were two flowers less than a thousand and there was no time to collect more flowers to make it a thousand. Suddenly, Goddess Lakshmi remembered that her husband, Lord Vishnu, had once compared her breasts with lotus buds. She decided to offer them to make up for the deficiency of the flowers. But, as she cut off one of her breasts, Lord Shiva appeared. Shiva was very much moved by her devotion and turned the cut breast into a round fruit— the 'Bel' — and sent it to earth to grow near his temples.

According to a Tantrik folklore, Lakshmi was born as a sacred cow and from her dung arose the 'Bel' or 'Bilva' tree. Lakshmi is seen with a fruit of this tree in her lower left hand in the 'Bhuvaneshwari Tantra'. This signifies that she is the deliverer of the fruits of action (Gandhi and Singh 1989).

Another interesting legend is that once a king saw a Brahmin offering Bilva fruits to the 'God of Fire', for a long time, in the hope of receiving a golden Bilva fruit as a boon. But the God of Fire was not moved by his prayers. The king then proposed to make the offering himself. He told the God of Fire that if he was not satisfied with the fruit of Bilva, the king would offer his own head. At this offering the God arose from the sacrificial fire with a golden Bilva fruit in his hand. As to the question why the God appeared so swiftly for the king and kept the Brahmin waiting, the answer is : "In this world success comes quickly to those who have fierce spirit and comes slowly to those who have dull spirit like the Brahmin".

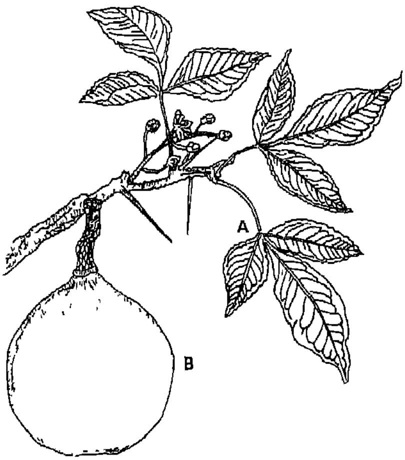


FIG. 2.3 A, B
Bel, *Aegle marmelos. A* Trifoliate leaves. *B* Round, hard-skinned fruit.

There are some common sayings also about this plant · "*Nera Bel Talai Jaya Kauber*" means, "How many times does the bald-headed go under the tree of Bilva?" It appears that the Bel fruit cannot resist a chance to fall on a bald or shaven head. Another Bengali proverb is : "*Bel Pakle Kaker Ki*" i.e., "How does it matter to the crow if the Bel fruit is ripe?"

It is impossible for the crow to peck the hard outer shell of the fruit.

Bel or Bilva is *Aegle marmelos* (Fig. 2.3 A,B) of the family Rutaceae. It is a medium-sized tree with a rough, grey-brown bark and branches with pointed thorns on them. The trifoliate leaves are shiny; flowers greenish-white, in bunches, and sweet-scented.

Aegle is a Latin name for one of the three sisters of Hesperides who — aided by a dragon — guarded the golden apple belonging to Hera. It is one of the very useful trees; almost every part of it is used in some way or the other. A gum is obtained from the stem. The sweet, aromatic pulp of the ripe fruit (Fig 2.3 B) is edible. The mucilaginous coating around the seeds is used with lime as a cementing mixture. It is used in varnishes and in water paints as a drier and to give a glossy finish; it is also used as an adhesive. The fruit pulp is made into sweet drinks (sharbats), very useful as a soothing agent for the delicate intestines of those suffering from bacillary dysentry. Half-ripe fruits are used as an astringent, digestive, stomachic and in diarrhoea (Singh et al. 1990).

Sacred Basil

Ancient folklores have accorded the basil somewhat mixed attributes. In Italy basil signifies love, in Greece hate, and in Jewish lore basil was said to give strength during long fasting. In India tulsi plants were grown outside temples because it has the unique property of quenching thirst. A weary traveller may keep a couple of leaves under the tongue and feel less thirsty. However, as time passed, people forgot that this was the reason why tulsi was planted near temples and the plant itself acquired a religious significance.

It is considered essential to use tulsi leaves in the worship of Hindu Gods and Goddesses, especially Lord Vishnu. According to *Padma Purana*, even the soil around the tulsi plant is holy. The belief is that the soul of a dead person whose body had been cremated with tulsi sticks attained a permanent place in Vishnu's abode and is not reborn. If a lamp is lighted for Vishnu's worship with a single tulsi twig, it is considered equivalent to several million lamps.

Tulsi is considered an incarnation of Radha, Krishna's beloved. Vrinda is yet another name for Radha and the Mathura forest where

Krishna played in his childhood with her is 'Vrindavana' or the Garden of Radha or Tulsi.

The Tulsi is also called the 'Little Shrub Goddess' and is a symbol of devotion and surrender. The belief still persists that a tulsi plant is essential to a home to ensure happiness.

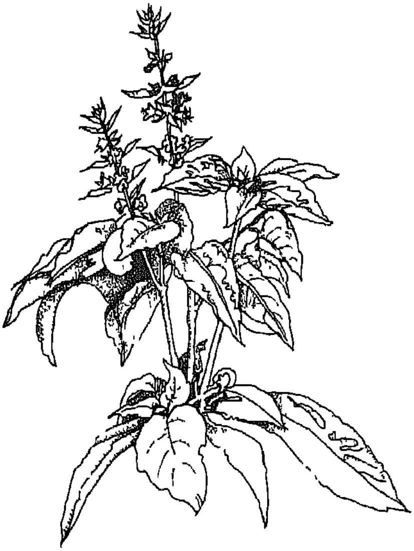


FIG. 2.4
Sacred Basil, *Ocimum sanctum,* twig with inflorescences.

The botanical name *Ocimum* is derived from the Greek word *Ocymium* (meaning 'sweet herb'). *Ocimum sanctum* (the scientific name) is a much-branched erect herb or undershrub (Fig. 2.4), up to about 75 cm high, with hairs all over the plant-body. The leaves oppositely placed on the stalk are three to five cm long, margin entire or toothed, hairy on both the surfaces, dotted with minute glands. The flowers are small, bilabiate, purplish or reddish, in small clusters arranged in a spike. The fruits are nutlets, seeds small and yellow or reddish.

The leaves and seeds have medicinal value. The juice of both leaves and fruits is used as a remedy for cough and cold. The oil of the leaves destroys bacteria and keeps away insects. The plant is an effective fly- and mosquito-repellent.

Some other species of *Ocimum* also have medicinal value. *Ocimum americanum* (Hoary Basil) occurs throughout India, near agricultural fields and waste places. The black seeds are used medicinally as tonic and diurectic. The oil extracted from the leaves has similar properties as the oil from the leaf of *Ocimum sanctum*. *Ocimum basilicum* (Sweet Basil) is an aromatic herb, common in north-western India, and cultivated in other places. Its leaves are used for flavouring and the seeds used in dysentry and chronic diarrhoea. The juice of the leaves is used as a nasal drop and applied in skin diseases.

An exotic Kenyan species is *Ocimum kilimundscaricum* (Camphor Basil). It is cultivated in West Bengal, Assam, Tamil Nadu, Karnataka, Kerala, Kashmir and Uttar Pradesh. The leaves are the source of camphor. Camphor is used in medicines, for local application on pains and sprains. *Ocimum gratissima* (Shrubby Basil) is a common, ornamental shrub, used as a mosquito-repellent and has been suggested as a measure of biological control of mosquitoes.

Bodhi Tree

The Bodhi tree is the most sacred plant at Bodh Gaya (Bihar, India). It is said that in the friendly shade of this tree Buddha obtained the perfection of wisdom. This tree is, therefore, named as the 'tree of knowledge' or 'Bodhidruma' and is a tree of 'pippala' (in Sanskrit). (Figs. 2.5 A,B and 2.6).

There are many interesting episodes concerning this plant. The tree sheds all its leaves only on the day of Buddha's nirvana, and slowly it attains its original condition.

When Ashoka became the king, he was not a follower of Buddhism. In fact he tried to destroy everything concerned with Buddha. He cut down the Bodhi tree — the root, trunk, branches and the leaves were piled up and burnt. But, as if it were a miracle, even before the flames and fumes dissipated completely, two new trees sprang up from the embers complete with stem, root and beautiful green leaves. King Ashoka was taken aback and repented for his crime. He revived the

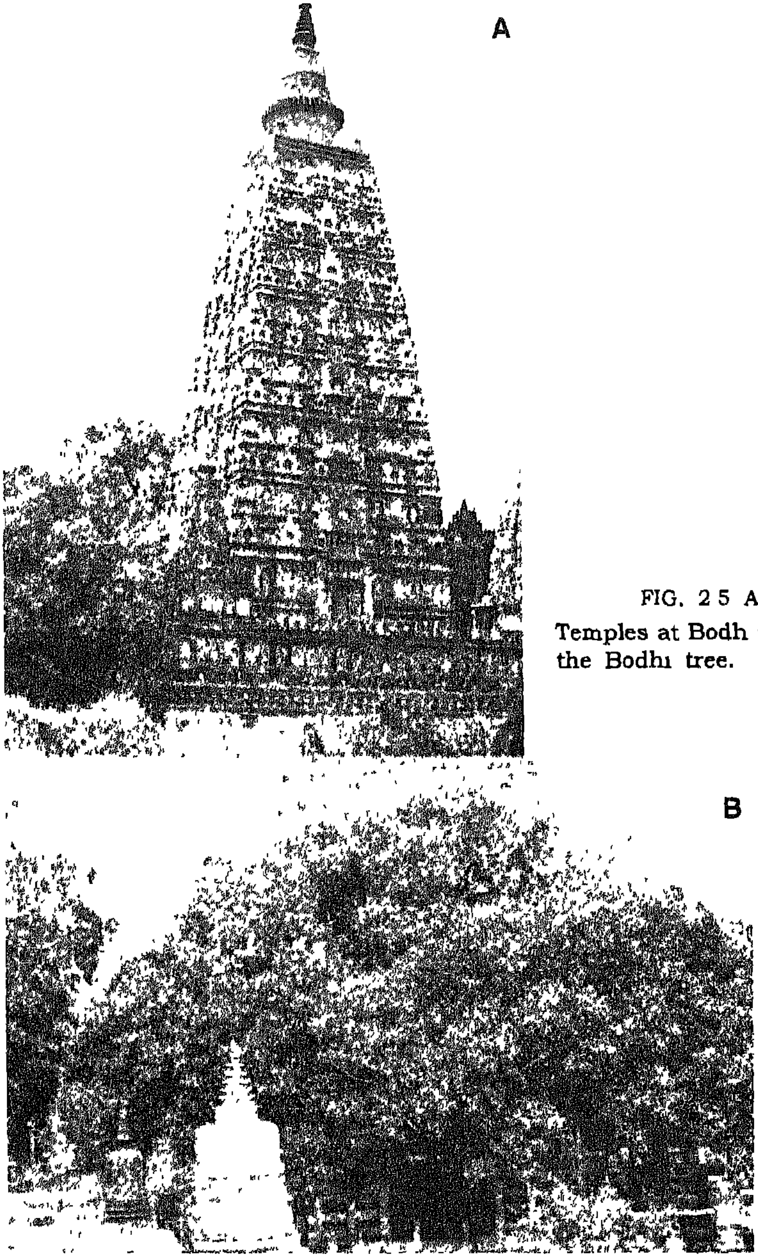


FIG. 2 5 A, B
Temples at Bodh Gaya; note the Bodhi tree.

small plant with plenty of 'perfumed milk'. It is said that the next day the tree attained its former state. The king was so delighted that he forgot to return home. This act of his, made his queen Tishyarakshita, envious of the tree, and she arranged to get it cut down a second time. The king was struck by profound grief when on the next morning he found that nothing but the bare trunk of the tree remained there. With his sincere prayers and offerings of 'perfumed milk' to the root, he could resuscitate the tree. This second destruction of the tree is mentioned in the Buddhist Sanskrit biography of Emperor Ashoka. He also erected a stone wall about 24 ft high around this tree so that nobody else could harm it.

The chronicles of Sri Lanka (erstwhile Ceylon) have recorded the ceremonial despatch by King Ashoka of a branch of the Bodhi tree for planting in Ceylon. The contemporary ruler of Ceylon sent his envoy to King Ashoka, the Maurya Emperor. A branch of the Bodhi tree with roots was given to the envoy who returned amidst great rejoicing of the king and the people. This tree was the awe-inspiring object of worship and was planted ceremoniously in the heart of the island country. This transplantation served as the living and growing symbol of friendship and cultural relationship between India and Sri Lanka.

There is another interesting account of the planting of a Bo-tree in the compound of the Jetavana monastery. The narration between the two disciples of Buddha makes it clear that importance was attached directly to the Bo-tree considered as a living symbol of the Master's presence and indirectly to the spot graced by it. Once when Gautama Buddha was away on pilgrimage, the devotees from nearby areas came to show their regard with fragrant wreaths and flowers. In his absence, they laid the wreaths and flowers at the doorway of the perfumed chamber and left. One of the disciples then sought the permission of Buddha for planting a Bodhi tree in the great monastery of Jetavana so that the devotees could show their reverence at least to the tree — the living symbol. For planting this tree, he received a fruit of the Bodhi tree from a senior disciple, Ananda. This incident shows that the tree is also grown from seeds (Barua 1981).

The botanical name is *Ficus religiosa*. *Ficus* means 'fig', and *religiosa* because the plant is worshipped. The Sanskrit name 'Ashvattha' means 'under which horses stand'. Another term 'Bodhidruma' means the 'tree of perfect knowledge' or 'Samyak Sambodhi'. The Hindi name 'Pipal' and Sanskrit name 'Pippala' has an interesting origin. To some extent, the leaves of the Pipal resemble those of Poplars — both morphologically and in their nature of rustling. The Aryan immigrants coming from the northern latitude named this plant 'Poplar' or 'Pappel', a tree they were familiar with. In Italian the Pipal is known as 'Populo delle Indie', i.e. the Indian Poplar (Gandhi and Singh 1989).

From the point of view of antiquity as well as religious fervour, *Ficus religiosa* is important. In the *Ramayana* it is mentioned that Rama stayed with Sita and Lakshman at 'Panchavati'. This name suggests that the forest was composed of five varieties of trees and they included *Ficus benghalensis* and *Ficus religiosa.*

The sacredness of the tree is mentioned in the great epic *Mahabharata*: "Ashwattha, having its roots below and branches above is eternal. He who knows it, knows the Vedas. Downwards and upwards are stretched its branches which are enlarged by the qualities; its sprouts are the objects of sense. Downwards, its roots leading to action are extended to this world of men". According to some authors who translated the original *Mahabharata*, "upwards and downwards are stretched its branches" means it looks after the highest to the lowest of created things; and "the roots extending downwards" means that these are the desires for diverse enjoyment (Gupta 1971). In the 'Gita', the Ashwattha is supposed to typify the universe. It is considered to be a sacred tree associated with the three Gods — Brahma, Vishnu, and Maheshwara, the Triad. 'Ashwattha *Stotra*' recited by people in praise of this tree says : "Oh Ashwattha tree, I bow to you — to Brahma in your root, to Vishnu in your trunk, and to Maheshwara in your foliage (leaves)". According to another myth, Vishnu was born under a pipal tree and is itself considered a deity.

The Brahmins often offer prayers under a Pipal tree saying that the Ashwattha tree is the king amongst trees; it is the emblem of the Triad — Brahma, Vishnu, and Maheshwara. All those who honour this tree by performing 'parikrama', i.e. walking around it, and singing in its praise would have the burden of their sins lessened in this world, and be blessed in the next.

The tree is regarded as a symbol of the male and is often married to the Neem tree, a symbol of the female. Villagers, in many parts of India, worship these trees on 'amavasya', i.e. the new-moon day, more so if it is a Monday. In Orissa the situation is a little different. Here, Vata or *Ficus benghalensis* is considered the male and Ashwattha as the female. In many places these two species of *Ficus* grow together. This is because the fruits of both these plants are eaten by birds, and the seeds pass through their alimentary canal unharmed, and germinate in odd places — in crevices on wall, or on roofs of buildings, or in an opening on the branch of a tree. Very often, we see these plants of Vata and Ashwattha growing on roof-tops, on the projections over balconies, or even one plant on the other.

There is an interesting story from the Muria tribals which tells us why the leaves of the Ashwattha or Pipal rustle in the breeze

God made men, animals and trees. Men increased in number and strength and they started grouping themselves in different villages. To maintain law and order, God gave them a king. The king with the help of his associates, made a government and ruled properly. God also made one chief and one watchman for every village.

When the animals increased in number the same treatment was given to them also.

Now it was the turn of the trees. They all assembled on Himagiri mountain to request God that they also be provided with a king who would protect them when needed. At that time Bhima was passing by and wondered why the trees had all assembled there. When he came to know about their problem, he decided to find out who was the strongest amongst the trees so that it would be easy for God to assign their duties. One by one, Bhima knocked down all the trees except Tamarind, Banyan and Ashwattha. Bhima informed God about the test of strength of the plants. Then God came down to Himagiri mountain to announce that the Tamarind would be the King, Banyan with its branches spreading far and wide could collect information and so he would be the Minister, and Pipal would be the Watchman. His duty was to give a warning to all other plants whenever there was a high-rising wind or an approaching storm. That is why, it is said, that the leaves of the Pipal rustle whenever there is breeze.

Ficus religiosa (Fig. 2.6) is a very large tree with a smooth grey bark that peels off in patches. The smooth and shiny young branches bear the betel-leaf-like leaves on long stalks. The leaves, bright-green and shiny with tapering apex, hang downwards and move with the slightest breeze to make the typical rustling sound. The invisible flowers are actually borne inside the small figs in pairs in the leaf

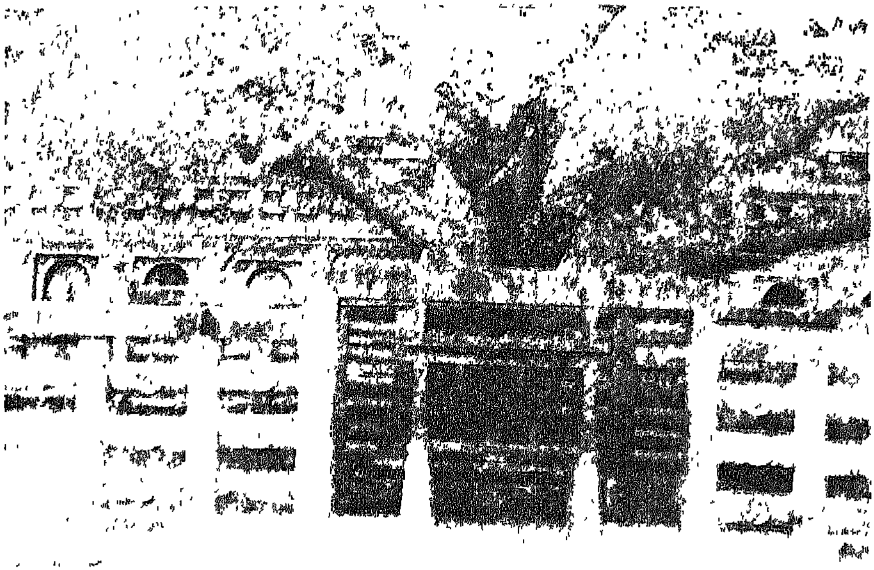


FIG. 2 6

The tree in the foreground is the Bodhi tree, *Ficus religiosa;* the stone wall around it was erected during Emperor Ashoka's reign.

axils. The ripe fruits (figs) are eaten by birds.

The Pipal plant is useful in Ayurvedic medicine. Although the plant as such is never cut down, its leaves are fed to camels and elephants. The bark (in ancient times) was used as cloth — the 'valkal' of *Ramayana.* The bark is also a rich source of tannin.

Mango

The mango tree is one of the sacred plants amongst both Hindus and Buddhists. This plant has been mentioned in works of ancient literature such as the *Ramayana,* many of Kalidasa's dramas, and in the *Jataka Tales.* In the *Ramayana,* it is termed 'Rasala' i.e. a juicy fruit. All parts of the plant are used in religious ceremonies; the leaves are the most important. Festoons of leaves decorate the doors of houses where there is a celebration of an event, be it marriage, purchase of a new house, or the birth of a child. The twigs of the mango plant with five to seven leaves are used in almost every religious function. After the 'pooja', the priest often sprinkles holy water on everybody, using mango leaves, called 'amrapallav' chanting mantras to bring peace to everybody—everywhere.

The wood is included in funeral pyres as well as in 'Homa' after any religious observance. The flowers are offered to the moon and also to the God of Love, Kamdeva. The inflorescence of mango forms a part of the offering to Goddess Saraswati, the Goddess of Knowledge, along with the inflorescence of barley (*Hordeum*) and the white flowers of kunda (*Jasminum multiflorum*).

There are many mythological stories associated with the mango tree. Once upon a time, the daughter of Surya Dev, the Sun God, who was married to a handsome king, was strolling in the nearby forest. Suddenly, she realized that she was being chased by a Rakshasi (demoness). To avoid being caught she jumped into a pool and changed herself into a lotus flower. Her follower could not swim and therefore did not enter the water but kept guard over it.

As her husband loved her dearly, he came looking for her everywhere. When he saw the single lotus flower growing in the pond, he waded through the water and plucked the flower. The Rakshasi was waiting for this opportunity and she came forward and promptly burned the flower to ashes. The king threw away the ashes near the pond and from this grew a mango tree. Fruits were borne on this tree, a few years later. The king happened to pass through the same area once more. And this time he collected one of the fruits and took it back to his courtiers. As he was handing it over to his minister, it fell on the ground and burst open. From within came out the long lost wife of the king.

Yet another story is from the *Jataka Tales*. Once upon a time, Buddha was born as the king of the monkeys — 'Mahakapi'. He lived on a mango tree in a thick forest on the banks of the river Ganges along with his eighty thousand followers. They enjoyed the fruits of that tree and were instructed by the king not to let a single fruit fall on the ground, as once men tasted this fruit they would kill the monkeys or chase them away. One day, however, one fruit fell in the river and floated downstream.

Brahmadutt, the King of Kashi (now Varanasi) was bathing in the river He picked up the fruit and was enchanted by its sweet fragrance and taste. Very soon he wanted to possess the tree and sent his men everywhere in search of the tree. Those who followed the course of the river, traced the tree after sometime. It was laden with fruits but the monkeys were also present. King Brahmadutt ordered his men to kill all the monkeys.

'Mahakapi' had to think of some method to save his followers. He climbed a branch of the mango tree which streched to the other bank of the river and springing from it he reached the other side. He then cut a bamboo and joined it with the branch to make a bridge so that all the monkeys could escape by that route. The bamboo was a little shorter than the required length, so 'Mahakapi' lay down himself to complete the bridge. Thus the monkeys were safely sent to the other bank of the river. But there was one amongst them, Devadatta, who was the cousin of Buddha and did not like him at all. When it was his turn to cross, he stamped on the back of 'Mahakapi' so heavily that it broke. King Brahmadutt had been watching this and had great admiration for 'Mahakapi' who sacrificed himself to save his followers.

Seeing him in pain, the king asked his men to bring him down. 'Mahakapi' was looked after well and after advising Brahmadutt about his duties towards his subjects, he died. Afterwards King Brahmadatt got a shrine made at the foot of the mango tree in honour of 'Mahakapi', the king of the monkeys in that incarnation.

There is another legend amongst the villagers of Uttar Pradesh. If a mango tree does not bear fruit for long, the owner of the tree walks up to the tree with an axe to threaten it. Along with him come a few of his friends also. Scolding the tree for not bearing fruit, he hits the trunk with the axe. His friends try to pacify him and request him to spare the tree and assure him that it would behave properly. The man, however, is not pacified and gives a second blow to the trunk of the mango tree with his axe. The friends come in between the tree and the man and implore him to give another chance to the tree. When the man leaves after much persuasion, the friends tell the tree that they had saved its life for the time being but it must bear plenty of fruits in the coming season. Surprisingly enough, people of these areas say that the method never fails ! (Gandhi and Singh 1989)

According to a Burmese legend, a gardener once presented a large mango fruit to Buddha. After the fruit was cut and eaten, Buddha handed over the seed to his disciple Ananda to plant it in a suitable place. After this, Buddha washed his hands where the seed was planted and soon there was a fully mature mango tree with flowers and fruits. This story has been engraved in the famous Barhut Stupa.

That mango was cultivated in ancient India is evident from its representation in many of the Buddhist Stupas of about 110 B.C. Descriptions of mango trees are given in ancient Sanskrit literature. In *Abhigyana Shakuntalam* by Kalidasa, Shakuntala has been compared

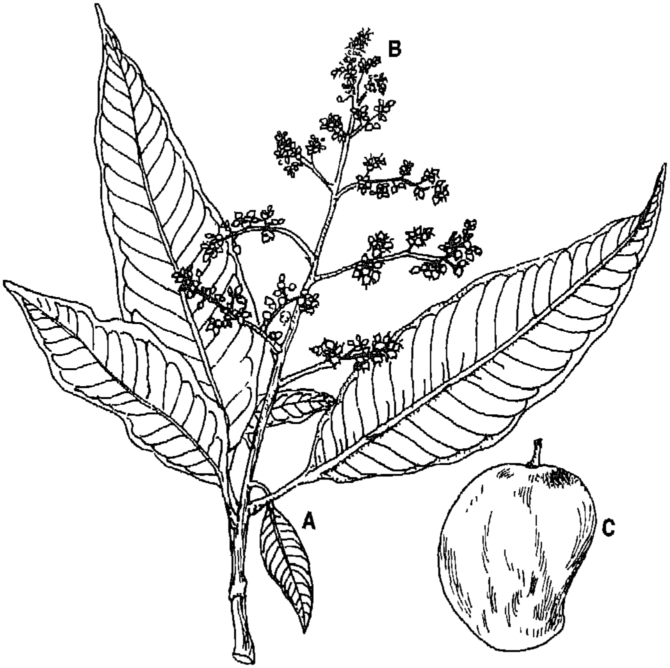


FIG. 2.7 A—C
Mango, *Mangifera indica*. *A* Leafy twig. *B* Inflorescence. *C* Fruit.

to a creeper of *Jasminum* (vanajyotsna) and king Dusyanta to a mango tree (sahakara). Urdu poets also have written beautiful verses in praise of the mango, particularly its blossoms and fruits. It is said that the Mughal Emperor, Akbar, who had learnt about the mango from these verses, wanted to know how it tasted. In answer, one of his courtiers said that if tamarind and molasses were mixed together it would produce the taste of mango. But it is a very poor comparison — the fruit has numerous varieties and endless types of fragrance and taste.

A native of southeast Asia, mango (*Mangifera indica*, Fig. 2.7 A-C) has been under cultivation in India for more than 4,000 years. The Persians introduced it into East Africa by the tenth century and the Portuguese colonists carried it to Brazil from India around 1700. From Brazil, mango seeds reached West Indies in 1742 and from there to Mexico in the 1800s. The Portuguese took it to tropical Africa also. From Mexico, and also from India, the mango was introduced to Florida in the nineteenth century. At present it is cultivated almost all over the warmer regions of the world. India surpasses all other countries in the number of varieties and richness of flavours.

The mango tree is large, evergreen with a beautiful thick canopy; the leaves are stiff, narrow, leathery and glossy, often fragrant; the flowers are yellowish-green with a pink-purple basal portion, borne in panicles at the end of the branches. The fruit is ovoid-oblong, slightly asymetrical, green when unripe, turning yellow or reddish-yellow when ripe. The largest mango tree in the world is said to be in a village Burail in Ambala (Punjab, India). It has been called '*Chhappar*', i.e. the thatched-roof, probably because it provides shelter to so many birds, animals, and men. The area covered by the crown is 2,700 sq yards and its average annual yield is around 175 quintals of fruit (Gandhi and Singh 1989).

3

The Beautiful Orchids

Orchids could be counted as the most beautiful flowers. The seventeenth century German botanist, Jacob Breynius, commented on the extreme structural variability of the orchid flower: "If nature ever showed her playfulness in (the) formation of plants, this is visible in the most striking way among the orchids. They take on the form of little birds, of lizards, of insects. They look like a man, like a woman, sometimes like an austere, sinister fighter, sometimes like a clown who excites our laughter. They represent the image of a lazy tortoise, a melancholy toad, an agile, ever chattering monkey. Nature has formed orchid flowers in such a way that, unless they make us laugh, they surely excite our greatest admiration."

The Chinese had been growing some orchids, more precisely, a few Cymbidiums, for quite some time, even as early as 500 B.C. Naguno (1960) reported that in the oldest book on Chinese philosophy *Eki-Kyo* (Book of Change), of which Confucius (551-479 B.C.) was one of the authors, mention has been made of 'lan', orchid in Chinese. In the *Materia Medica* of the Chinese emperor Shen Nung (twenty-eighth century B.C.) mention has been made of *Dendrobium* and *Bletilla hyacinthina.* But it was only in 1731 that the first orchidaceous plant entered the Western world. This plant was *Bletia purpurea* and it was sent to an English gardener, Peter Collision, in the same year from the Bahamas. A few years later, some species of *Vanilla* entered the English collection. For a long time, the methods of cultivation

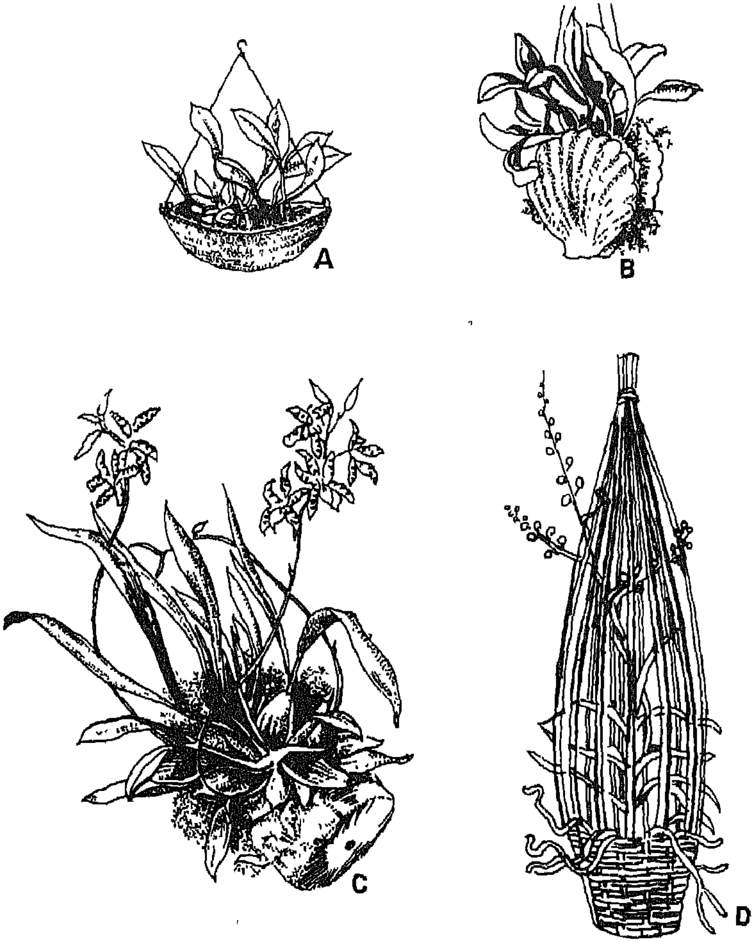


FIG. 3.1 A–D
A, B Baskets used by Loddings (ca 1810).
C Miltonia clowesii on a block of wood (1842). *D* Basket used by Sir Joseph Banks (1817) for *Sarcanthus paniculatus*.

of the orchid were far from satisfactory. They were mostly treated so harshly that they perished before producing flowers.

In 1778, Dr John Fothergill brought living specimens of *Phaius tankervilliae* and *Cymbidium ensifolium* from China, and the former flowered after a short period. *Epidendrum cochleatum* bloomed in England in 1787, and the next year another species, *E. fragrans*, flowered in the Royal Botanical Gardens at Kew. These plants were grown in such conditions that it was a wonder that they not only survived but also flowered. They were grown "in pots of earth composed of rotten wood and decayed leaves, plunged into the tan bed of a pit."

By 1794, about 15 species of orchids — mostly from the West Indies region — were growing at the Kew Gardens. The collectors had observed that these plants were growing on trees and therefore presumed them to be parasites. These poor epiphytes were given very wrong treatment like growing them in pots filled with decayed wood and leaves and subjecting them to extremely high temperatures and moisture.

Serious attention to orchid cultivation was given only after 1809, when the Horticultural Society of London was founded. The first English farm to grow orchids for sale was Messrs Loddings. It was the 'epiphytic orchids' which posed a problem for the early growers. It was Mr Fairbairn whose method was suitable for the survival of these epiphytes. He placed the plant in a basket with tan-bark and moss (Fig. 3.1 A-C). This was hung up in the pine house where it received both sunshine as well as 'fire-heat' (high temperature) in winter. Water in a large container was also placed nearby in which the basket could be plunged six or seven times a day.

Cylindrical wicker baskets (Fig. 3.1 D) were suggested by Sir Joseph Banks in the 1920s. John Lindley proposed a number of culture practices in 1830 which when followed blindly gave disastrous results. His suggestion was to arrange for high humidity and excessive temperature inside glass enclosures — the green houses. Aptly, they were called "stoves". For more than half a century, England was, as Sir Joseph Dalton Hooker once observed "the grave of tropical orchids."

Reforms in orchid culture were brought about in 1835 by two persons: Joseph Cooper, the gardener of Earl Fitzwilliam at Wentworth, Yorkshire, and Joseph Paxton, the gardener of the Duke of Devonshire at Chatsworth. Lindley visited Chatsworth in 1838 and commented, "the success with which epiphytes are cultivated by Mr Paxton is wonderful, and the climate in which this is effected, instead of being so hot and damp that the plants can only be seen with as much peril as if one had to visit them in an Indian jungle, is as mild and delightful as that of Madeira" (Hawkes 1961).

Confucius, the Chinese philosopher, once said that acquaintance with good men is like entering a room full of fragrant 'lan' (orchid). The Javanese people believed that their jewel orchids were pieces torn from the jewelled cloak left behind by a fairy princess who had to take off in a hurry after one of her visits to this world.

The Thai Airways presents an orchid to all its outgoing passengers.

At the Honolulu airport, young, charming women greet incoming passengers with garlands of orchid flowers.

Orchids belong to the monocotyledonous family Orchidaceae, the largest of all flowering plant families. It contains approximately

1,000 genera and 15,000 to 20,000 species (Jones and Luchsinger 1987), and an even greater number of hybrids is now on register. Orchids are perennial herbs, shrubs, vines or even grass-like. They may grow in the ground, on rocks, or perched on trees or shrubs. A few orchids grow in water as semi-aquatics (*Ipsea malabarica* in open marshy land), and two extremely rare and unusual genera, the Australian *Cryptanthemis* and *Rhizanthella*, are subterranean with only the tiny flower-heads above ground.

The usual belief is that orchids grow only in the tropics, particularly the excessively hot, humid dark and 'mysterious' areas of the rain forests. This, however, is not correct. Orchids grow almost all over the world, even in the extremely cold, bleak meadows of Patagonia (Argentina), the frigid dales of Alaska, the snow-covered summits of the Himalayas, the parched sandy deserts of Australia and Africa, and as semi-aquatics in the tannin-stained streams of the south-eastern states of America (Hawkes 1961).

New Guinea has the maximum number of native orchids, followed by Columbia, Brazil, Costa Rica, Borneo, Java, and the Himalayas in India.

In the warmer regions the orchids mainly grow as epiphytes, i.e. they grow perched on trees or shrubs and cling to them with the help of their special roots but do not derive any nourishment from the support. Many others grow equally well as lithophytes, i.e. on barren rocks or cliffs to which their roots remain attached. Near Rio de Janeiro (Brazil), the precipitous cliffs of the mountains show thick carpet-like growth of various orchid genera such as *Cattleya, Laelia, Pleurothallis, Epidendrum* and *Oncidium* alongwith lichens, mosses, ferns, Bromeliads (members of Bromelliaceae), gesneriads (members of Gesneriaceae) and many others.

The orchids of temperate zones are usually terrestrial and they derive their nourishment from the soil with their normal roots. There is yet another group — the saprophytes — which grow on dead and decaying animals and vegetable matter, for example, *Corallorrhiza, Galeola* and *Hexalectris.*

Orchid plants, like their flowers, show a large range of size. Certain species of *Bulbo-phyllum* (Fig. 3.3 B) measure less than three-fourths of an inch in height, when fully mature. Whereas in *Gramatophyllum speciosum,* the 'queen orchid' of Indonesia - New Guinea region, the pseudobulbs (or rhizomes) are sometimes more than 28 feet long (Hawkes 1961). Vine - like orchids such as *Vanilla* (Fig. 3.2) and *Vanda* (Fig. 3.3 A,D)

FIG. 3.2

Vanilla, the vine-like orchid in the glasshouse at Royal Botanical Gardens, Kew, London. (*Courtesy.* A. K. Bhattacharyya)

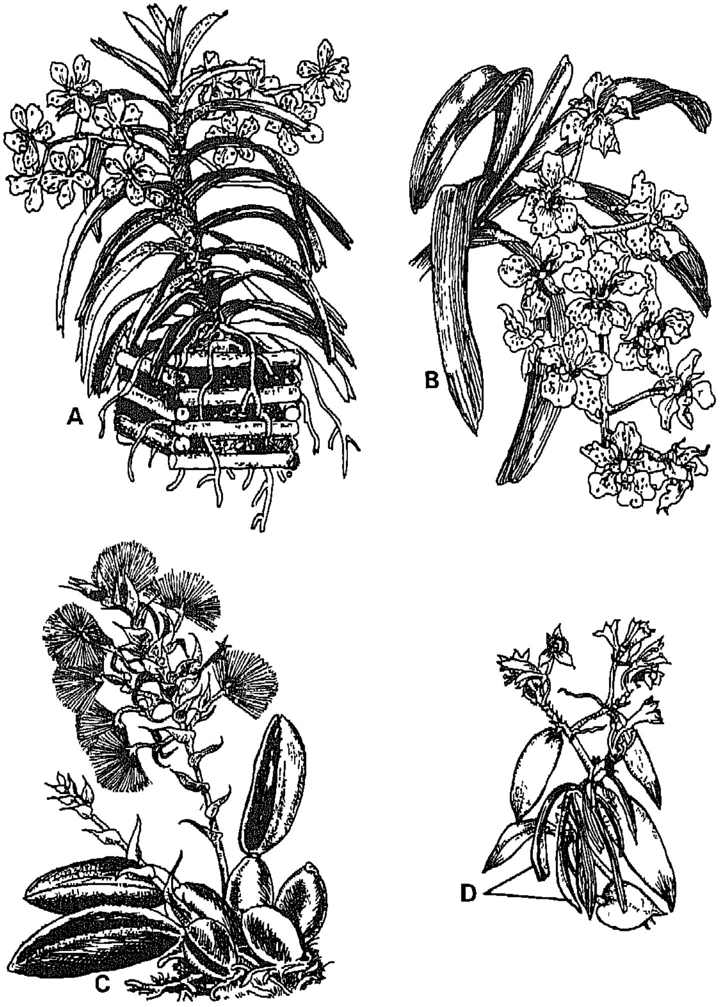


FIG 3.3 A-D

A Vanda, grown in a wooden basket. *B Vanda insignis,* one of the common Indian orchids. *C Bulbophyllum barbigerum,* a sympodial orchid. *D Vanilla,* pods are the source of vanilla essence.

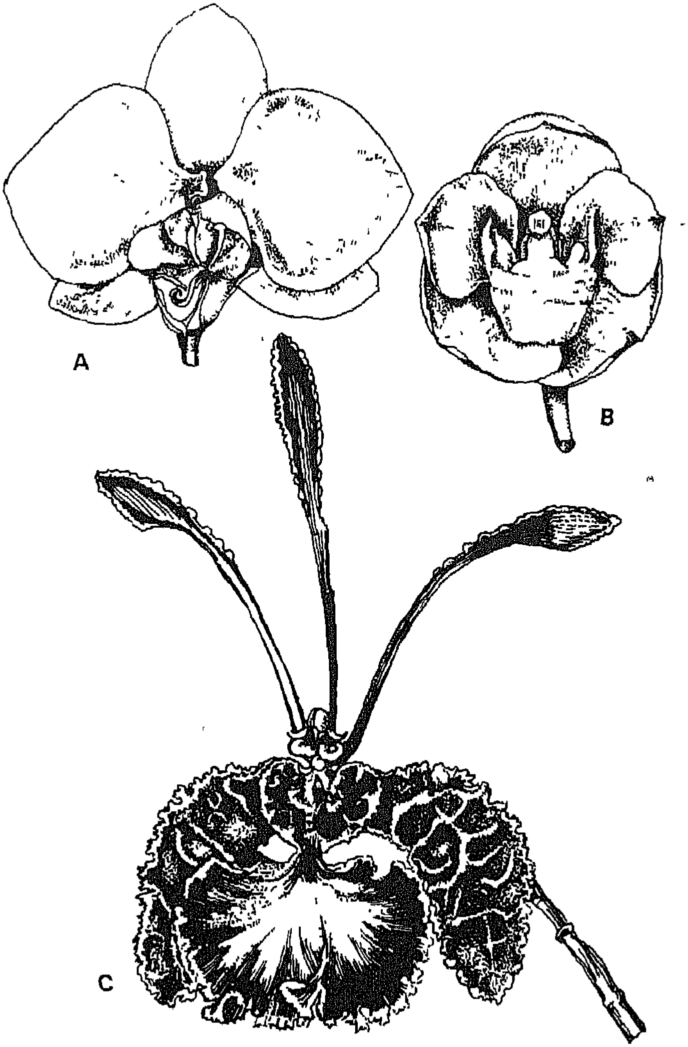


FIG. 3.4 A–C

A Moth orchid, *Phalaenopsis sanderiana-alba* resembles a moth.
B Dove orchid, *Peristeria alata* resembles a dove ready to fly off.
C Butterfly orchid, *Oncidium kramerianum* is so much like a butterfly.

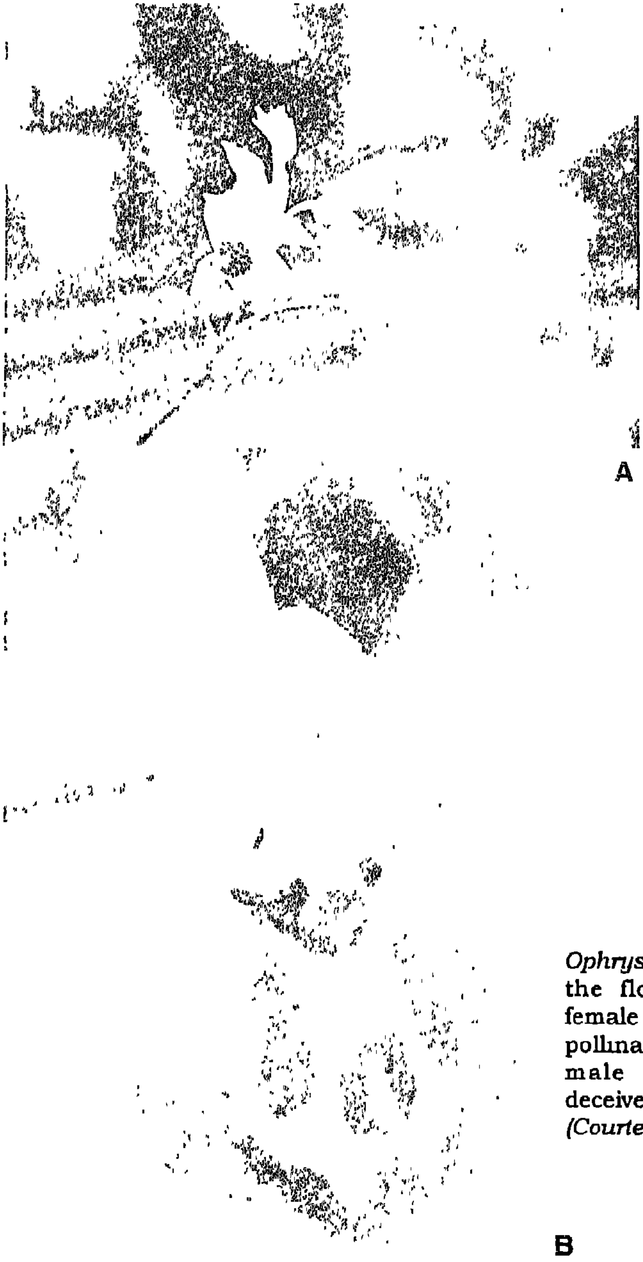


FIG. 3.5 A, B
Ophrys cretica, Spider orchid, the flowers resemble the female insect *Scolia ciliata;* pollination is done by the male insects which are deceived by this resemblance. *(Courtesy:* A. Shukla)

may sometimes be more than 100 feet in length with numerous branches, forming almost an impenetrable mass. *Rhynchostylis retusa* is a herbaceous orchid with massive inflorescences (Fig. 3.7).

Orchid flowers, the most admired ones, probably exhibit all the colours of the rainbow. However, green and brown are the most common combination observed although white, yellow, blue, orange, scarlet, very dark purple or maroon, almost appearing black, are also known. They range in size from less than a sixteenth of an inch to more than a foot. Some give off a pleasant odour, some an unpleasant one and some are odourless. Many of the orchid flowers exhibit amazing examples of mimicry.

According to Dr Lindley, flowers of this group of plants are most irregular. "By an excessive development and singular conformation of one of the petals called the labellum or lip, by irregularities either of form, size or direction of other sepals and petals, by the peculiar adhesion of those parts to each other, and by the occasional suppression of a portion, flowers are so unusual and so grotesque in form that it is no longer with the Vegetable Kingdom that they can be compared, but we are forced to seek resemblances in the animal world."

Hebenaria blephariglottis of North America is commonly known as 'monkey face'; *Cycnoches*, native of Central America, as 'Swan orchid' as it resembles the gracefully arched neck of a swan. *Anguloa clowesii* is popularly known as 'Tulip orchid' because of the similarity of the blossoms to those of the garden tulips. *Anoectochilus roxburghii* of the Himalayas is the popular 'jewel orchid' with its magnificent, variegated, velvety foliage. The blotched, sleek appearance of the blossoms of *Ansellia* has been given the name 'Leopard orchid'. 'Scorpion orchids' are the *Arachnis* species of the Malaya Peninsula, so-named because of their multicoloured, strangely-formed flowers.

Phalaenopsis sanderiana-alba (Fig. 3.4 A) is the 'Moth orchid,' *Peristeria alata* (Fig. 3.4 B) the 'Dove orchid' and *Oncidium kramerianum* (Fig. 3.4 C) is the 'Butterfly orchid.' The flowers of *Ophrys cretica* (Fig. 3.5 A,B) resemble the female of the insect called *Scolia ciliata*. The male insects who visit the flowers are, thus, deceived thinking them to be the female partners, and pollination is achieved. Probably the best-known are the 'Lady's sipper orchid', *Cypripedium* with its shoelike flowers.

The odd shape of the flowers and other parts of the plants have

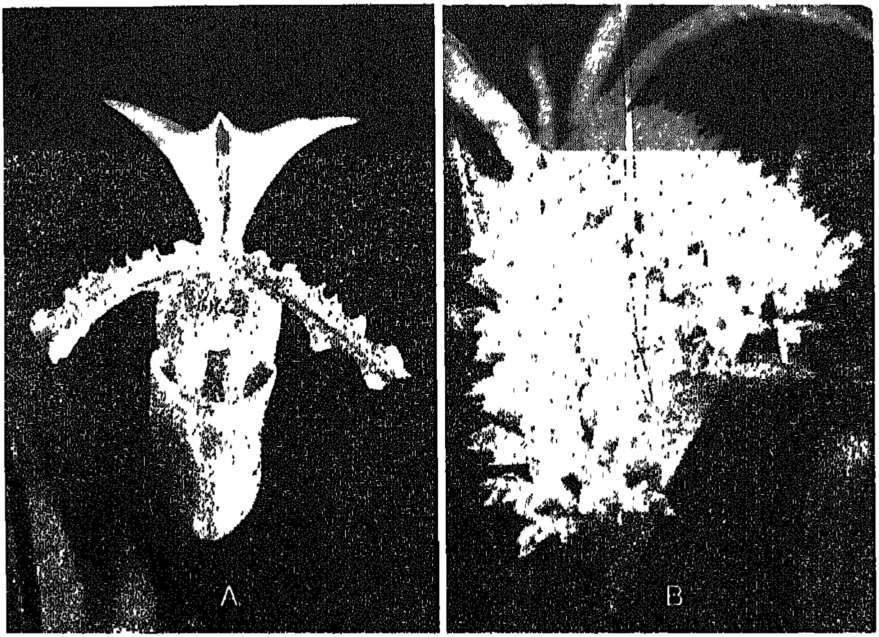


FIG. 3.6 A, B

A Paphiopedilum spicerianum from Assam, important for hybridization. *B Dendrobium secundum* from Malaysia and Siam. [Both photographed at Botanical Garden, Münich, Germany. (*Courtesy*. Shashi Tyagi)] suggested that they have magical and medicinal properties. Medieval European herbalists collected the roots of certain orchids, which they called 'dog-stone roots,' for the preparation of aphrodisiac potions. It was presumed that the sex of an unborn child could be predetermined by using orchid roots (Arditti 1966). The native Indians of North America boiled the roots of *Cypripedium* species — with some sweet substance like maple sugar — and drank the broth for headache and other simple ailments. On the Indonesian Island of Amboina, a paste made from the orchid *Grammatophyllum* is used as a remedy for sores. In Malaya a preparation from *Dendrobium* (Fig. 3.6 B) is applied for skin infections. In Africa the Zulus employ *Hebenaria* as an emetic. In South America *Epidendrum bifidum* is used to expel tapeworms, and *Spiranthes* as a diuretic. How far these treatments are effective is anybody's guess.

There are certain religious and superstitious beliefs associated with the orchid. For example, the flowers of the *Dendrobium maccarthial* are considered to be the lucky flower of Sri Lanka. This flower is used as temple-offering at a Buddhist festival during the month of May. The flowers are, therefore, locally called 'wesak mala' (May flower). In Borneo *Coelogyne asperata* is a sacred plant. In parts of Malaya *Cymbidium finlaysonianum* is used as a talisman to keep evil spirits away from the native villages. The seeds of *Grammatophyllum scirptum* of Molucca Islands are used in the preparation of an all-powerful love potion. The beauty, strange shapes and longevity of many orchid flowers, together with the comparative ease with which they can be cultivated, have made them the favourite of florists and horticulturists. The 'slipper' orchids — Venus slipper orchid (*Paphiopedilum venustum*), Villose slipper orchid (*P. villosum*), Spices Slipper orchid (*P. spicerianum*; Fig. 3.6 A) — are of horticultural importance. The production of flowers and plants for sale is a multimillion dollar annual business in the United States alone.

Vanilla, the popular flavour for ice-cream, milk-shakes and the like is obtained from dried, cured, full-sized but unripe fruits of an orchid named *Vanilla planifolia* (Fig. 3.3 C). In the international market this product is only second to saffron in terms of cost (Singh 1995). *Vanilla* is grown in most of the tropical regions of the world with the Malagasy Republic contributing nearly 80 per cent of the total world production.

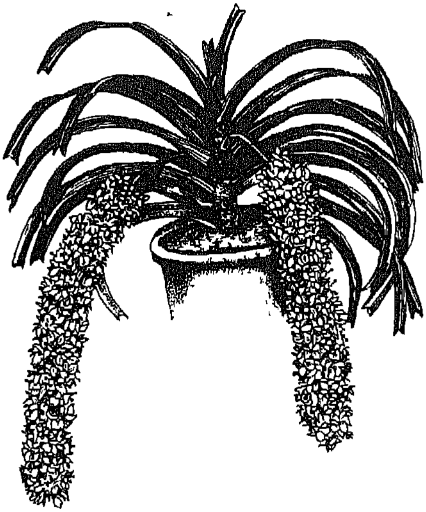


FIG. 3.7
Rhynchostylis retusa, a monopodial orchid with lateral raceme inflorescence.

'Salep' — another widely used bland food of great nutritive value — is obtained from the fleshy, succulent tubers of *Orchis* spp. In olden days, the succulent leaves of *Anoectochilus* were sold as vegetable in the local markets of Malaya and Indonesia. In the same area, dried pieces of the leaves of *Dendrobium salaccense* when cooked with rice, imparted a delicious aroma to the rice. 'Faham tea,' a popular beverage of the Victorian period, is a product of the orchid *Jumellea fragrans*, a native of the Mascarene Islands.

A number of orchids have been portrayed on postage stamps. In 1937, Costa Rica issued a stamp depicting *Cattleya skinneri*, and Brazil, in 1946, portrayed *Laelia purpurata*. Columbia released a of the native orchids. The 'Wesak Orchid', the 'lucky flower' of Sri Lanka, has been depicted in their stamp. The orchid *Cypripedium* was honoured by USA through a stamp to mark the occasion of the eleventh International Botanical Congress held in 1969 at Seattle. The ornate flowers are used for corsages.

The term 'orchid' was coined by Theophrastus during the Greek period. While describing a plant with paired roots that looked like testicles, he named it *Orchis* from the Greek word for testicles. Linnaeus adopted the name in his *Species Plantarum* published in 1753, and in 1836 John Lindley introduced the family name Orchidaceae (Arditti 1966).

One interesting point to note is that the Orientals (Chinese and Japanese) worshipped the orchids as something ethereal but the Westerners' emotions were of a different nature. A reason for this may be that, in China and Japan, the graceful *Cymbidiums* and *Dendrobiums* were large plants while the native orchids of the Western countries were mostly small, terrestrial plants with obscure heads of flowers. Even the name 'Orchid' is derived not from its beautiful, spectacular flowers but from the insignificant underground tubers seen only in a minority of these plants.

Ovule development in an orchid generally occurs only after and in response to the stimulation of pollination (Abraham and Vatsala 1981). The seeds of the orchid are tiny though this is compensated for by their vast number. According to Hans Burgeff of the University of Würzburg (Germany), their weight ranges from 0.3 microgram to 14 micrograms; average length approximately one mm and average diameter from 0.5 mm to 0.75 mm. The number of seeds vary from 1,330 per capsule in *Coeloglossum viride* to four million per capsule in a variant of *Cycnoches ventricosum*

(Arditti 1966). Charles Darwin once stated that if the viable seeds produced by a single *Orchis maculata* (6,200 per capsule and 186,300 per plant) were to germinate and grow to maturity, they would cover an acre of land, and the fourth generation descendants of the plants would cover the entire globe! But the truth is that most of the seeds fail to germinate. After the seed has reached a suitable growing surface, it undergoes several changes and forms a tiny corm-like structure, and awaits in this stage, sometimes even for 24 months, for a suitable fungal infection. Without this symbiotic relationship with fungus, the orchid seeds cannot grow further. A French botanist, Noël Bernard, discovered this fact quite accidentally. During a stroll in a forest he came across a bunch of germinating seeds of *Neottia nidus-avis* the European Bird's Nest Orchid. It was a matter of chance that he examined these seedlings and observed that they were infected by a fungus. It was his idea (in the beginning) that the fungus was symbiotic in nature and was necessary for the germination of orchid seeds. It has been experimentally shown by several orchidologists that the fungus apparently contributes certain enzymes and perhaps some vitamins and growth hormones that the orchid seed needs for development.

There has been a rapid expansion of orchid culture in recent years resulting from the increased appreciation of this beautiful and interesting group of plants. There are numerous species and varieties of orchids under cultivation at present and there will be many more in the future.

4

The Banana Family

MUSACEAE — the Banana family — comprises five genera and about 150 species, all tropical and mainly gigantic herbs. The genus *Musa* includes the banana, plantain and abaca.

About the banana, Alphonse de Candolle wrote in the *Origin of Cultivated Plants* (1883):

> The antiquity and wild character of the banana in Asia are incontestable facts. There are several Sanskrit names. The Greeks, Latins and Arabs have mentioned it as a remarkable fruit tree. Pliny speaks of it distinctly. He says the Greeks of the expedition of Alexander saw it in India and he quotes the name 'pala' which still persists in Malabar. Sages reposed beneath its shade, and ate its fruits. Hence, the botanical name *Musa sapientum*. *Musa* (Arabic 'mouz' or 'mawoz') finds mention as early as the thirteenth century in Eba Baithar.

Banana is one of the oldest fruits known to mankind. In the Koran and in Arab legends, it is described as the 'Tree of Paradise' in the Garden of Eden. The scientific name *Musa paradisiaca* is based on 'Muz' or 'Mouz' the Arabic word for banana.

Banana is mentioned in ancient Hindu scriptures dating as far back as 500 B.C. In the *Vishnu Purana*, it has been said : "As the bark and leaves of the 'Kadali' tree are to be seen in its stem, so thou art the stem of the universe and all things are visible in thee." 'Kadali' and 'Rambha' are the names of the banana in Sanskrit. It is considered auspicious and used in Hindu religious ceremonies. Entire plants are placed at the entrance of the houses when there is a marriage caremony.

There are a number of folk tales about the banana. In almost all families there is an exchange of 'hot words' between the mother-in-law and the daughter-in-law. Once it so happened that in Lord Shiva's family, one fine morning, Ganesha saw that his mother was eating a number of good dishes. He was rather surprised and wanted to know the reason for her eating in that manner. Parvati replied, "Who knows whether my daughter-in-law will let me have nice things to eat. So I am having them all today before your marriage takes place." Ganesha was perturbed to hear this and decided to marry a banana plant so that it would not be able to talk or do anything untoward but, at the same time, would give a large number of grandchildren (the fruits) to his parents. That is why at the time of Durga Puja, the banana plant is worshipped as a deity — the wife of Ganesha.

Another interesting story reveals why the banana plant bears fruits without pollination. Long back, there were five sisters named 'Mango', 'Tamarind', 'Fig', 'Jamun' and 'Banana'. When they came of age, their father wanted to marry them off. To know what their wishes were, one day the father called his daughters. All the daughters, except Banana, said that they wanted a husband and a number of children. But Banana's desire was to have children but no husband. Also, she wanted to get old sooner.

In course of time, the other four sisters got married and had so many children that their husbands ran away. Banana did not get married but bore fruits that were without seeds, i.e. parthenogenic fruits.

Another story from the *Mahabharata* says that when Lord Krishna could not amicably solve the problem of the Kauravas and Pandavas, he was frustrated about the outcome of the battle. For solace, perhaps, he went to the house of Vidura, the half-brother of Pandu and Dhritarashtra, and a very learned man as well. Vidura was not at home. His wife 'Viduri' welcomed him and offered bananas to him. But she was so excited by the presence of Lord Krishna at her threshold that unmindfully she discarded the edible part of the fruit, and offered only the skin to him. Lord Krishna did not mind and kept on eating the skin as they were offered to him with great devotion.

The bananas were grown in Southern Asia even before prehistoric times, and the world's largest diversity in banana population occurs in this part of the globe. It is, therefore, generally agreed that all the edible bananas and plantains are indigenous to the warm, moist regions of tropical Asia — India, Burma, Thailand and Indo-China. At the time of the invasion by Alexander the Great, more than 2,000 years ago, there were large banana plantations in the Indus Valley. Historical evidences confirm that it was the Arabs who took this plant across the Indian Ocean and introduced it into Palestine and Egypt, perhaps in the seventh century A.D. It became a very popular crop in these areas within a short time. The plant gradually spread to the East Coast of Africa, and subsequently all over the African continent. In support there are evidences from the first report of a European visit to this continent. When Captain Cook first embarked on his voyage to the Pacific Islands, several varieties of banana were already under cultivation in the Hawaiian Islands. This fact indicates early introduction of banana in those Islands. The banana is reported to have been introduced into Central America in 1516 A.D. Its

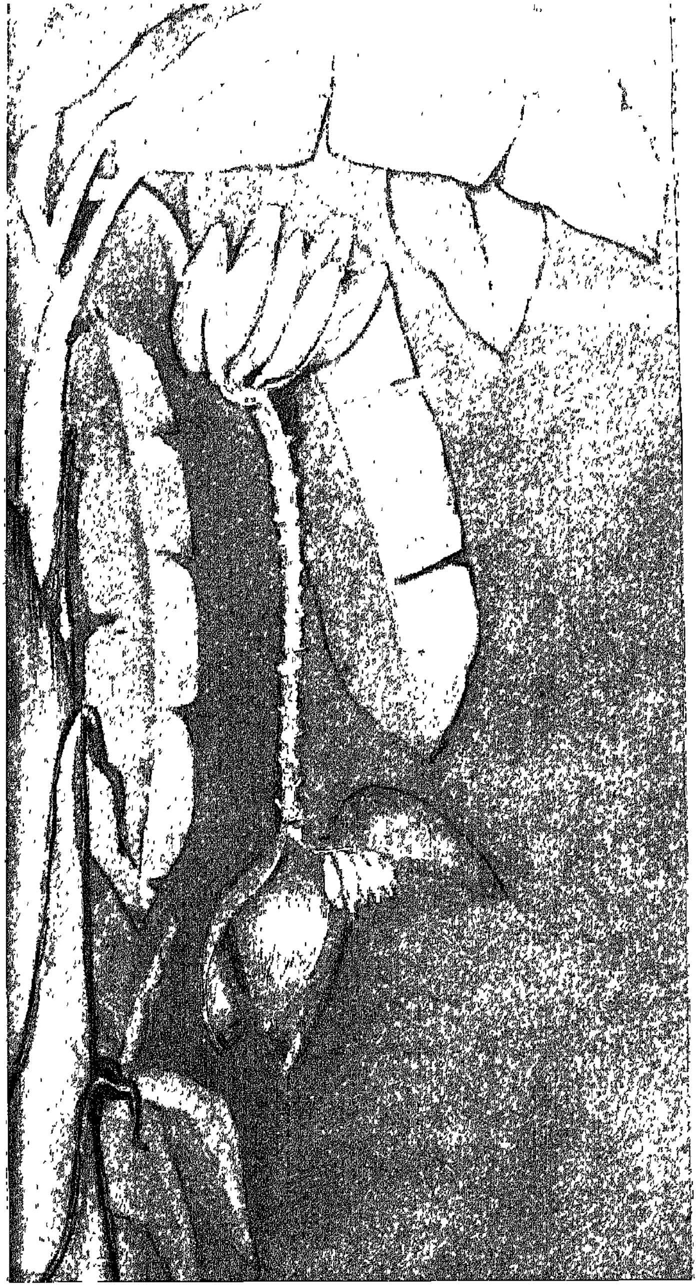


FIG. 4.1
Banana, *Musa paradisiaca,* inflorescence and fruits.

spread to West Indies Islands was effected with the help of Christian missionaries (Shanmugavelu et al. 1992).

The banana plants grow to a height of about four metres. The stout pseudo-stem is composed of the long, stiff but spongy sheathing leaf-bases, enclosing the soft peduncle. The leaves are spirally arranged on the underground large conical rhizome and the blades are crowded at the apex of the pseudo-stem. The leaves are 15 ft long and 3 ft broad when mature, completely undivided, when it opens. At the time of flowering, the aerial stem pushes through the centre of the leaf-sheaths, bears one or two smaller leaves and terminates in a spadix (Fig. 4.1) which may be erect or pendulous. The flowers of the banana are borne in the axils of large coloured bracts which are spirally arranged and are pollinated by various agents like bats, birds, butterflies and moths.

Edible Banana

Edibility in banana depends primarily on the occurrence of parthenocarpy or development of the pulp from the ovary without fertilization. Pulp development starts from the inner face of the skin — followed by swelling of septa and axis. Parthenocarpy is often accompanied by female sterility and therefore seedlessness. Parthenocarpy and sterility have in all probability arisen due to gene mutations in fertile diploids. Selection and vegetative propagation have helped in its establishment. Polyploidy leads to increased vigour and large-sized fruits.

Edible banana (*Musa paradisiaca-sapientum*) is believed to have originated from crosses between *M. acuminata* and *M. bulbisiana*. Both seeded (i.e. wild) and seedless (edible) forms of *M. acuminata* occur as normal diploid plants, in addition to the triploids. The edible forms are said to have arisen through the evolution of parthenocarpy and sterility in diploid forms and through outcrossing of edible diploids with wild forms of *M. acuminata* and *M. bulbisiana,* followed by human selection.

Through the occurrence of triploidy in *M. acuminata* and in crosses between *M. acuminata* and *M. bulbisiana,* there are two genetically distinct types of triploids. *M. bulbisiana* includes mainly diploid (n = 11) seeded types. Edible triploids do not occur in nature. The hybrid *M. x paradisiaca* are edible bananas and are valued for their seedless fruits. They comprise all the 2n, 3n and 4n clones, mainly hybrids of *M. acuminata* and *M. bulbisiana.*

The classification and nomenclature of the edible varieties of banana are highly intriguing. In earlier classifications, all edible clones were grouped under the two linear names — *M. paradisiaca* and *M. sapientum,* the former for culinary types and the latter for dessert types. After going through a large number of controversies, it has now been decided that the cultivated banana types may be classed under six groups, each designated by letters which indicate their ploidy and genomic composition with respect to the two parent species (*A* for *M. acuminata* and *B* for *M. bulbisiana*). *AA* and *AAA* stand for diploid and triploid derivatives of *M. acuminata*. *AB, AAB,* and *ABB* represent diploid and triploid hybrids, the first two with one and the third one with two genomes from *M. bulbisiana* combined with 1,2 and 1 genomes of *M. acuminata,* respectively.

Earlier classifications of *Musa* were based mainly on morphological features and on the edibility or inedibility of the fruits. These are not so well-accepted today in the light of recent cytogenetical and phyto-geographical studies. Ensete (n = 9) with features like single-stemmed monocarpic plant-body with swollen pseudo-stem bases should be treated as distinct from *Musa* (n = 10,11) with true stooling and cylindrical stem. The Section *Musa* (or

Enmusa) is the largest and geographically most widespread and includes majority of the edible bananas, mostly of hybrid origin.

The centre of origin of the banana group is mainly south-east Asia (Assam, Burma, Malaya, Thailand and Indo-China) with Malaya as the primary and India as the secondary centre.

Uses of the Banana Plant

Banana Stem: The tender inner portion or the core of the stem of the fruited banana plant is cooked and eaten as a vegetable.

Leaves : Fresh leaves are used extensively as platters. Peeled leaf-sheaths are used fresh or after drying as packing material for flowers, betel leaves, fruits, etc. They are stripped into shreds, dried and used for tying packages and making garlands. Banana fibre has been locally used in India for making cordage, mats and to some extent, coarse paper.

Flowers : The neutral and staminate part of the inflorescence (before it opens) is used as a vegetable.

Fruits : Both ripe and unripe fruits are consumed, the latter after cooking.

Banana Peel : Used as cattle feed, is comparable to good-quality hay in nutritive value. It is also a source of pectin.

The fruit has mild laxative properties. It also aids in combating diarrhoea and dysentry, and promotes the healing of intestinal lesions in ulcerative colitis.

Banana Products

Chips : Fully mature but unripe banana is cut into chips and fried in oil.

Flour and Powder : Flour from unripe and powder from ripe fruits can be used as infant feed.

Figs : Popular name for dried ripe fruits. Fermented products are also obtained from ripe fruits.

Abaca

In addition to the banana, another species of *Musa, M. textilis,* is important. One of the most valuable of all the fibres for cordage, is the fibres of this plant. These are nearly three-times stronger than cotton fibres, and two-times stronger than sisal fibres. This exceptional strength of the abaca fibre and its quality of resistance the action of salt water make it particularly suitable for marine cordage.

A native of the Philippine Islands, abaca has long been used as fibre by the native inhabitants. It became commercially important only when the supply of Russian hemp to Britain and the United States of America was cut off during the Crimean War (1854-56) (Kochhar 1981). Even in the Philippines, originally only wild plants were the source of the fibre but the increase in demand has led to the establishment of plantations.

The alternate name 'manila' or 'manila hemp' is a misnomer. It is not grown in Manila but the first shipment of the fibres to England was made from the port of Manila.

The plant closely resembles a banana (*Musa paradisiaca*) plant but it is perennial, more tufted, the stalks are more slender with narrower, lighter, more pointed leaves that are often spotted. It bears small, inedible fruits with numerous large black seeds. The erect pseudostems formed of 15 to 25 leafstalks, often attain a height of 6.1 m or more. The fibre is obtained from the leafstalks of abaca.

The superior grades of abaca obtained from the outer-layers of the leaf-sheath are used for marine cordage, ship caulking and in the fishing industry. It is also used for mining. The softer fibres from the inner layer of the leaf-sheath are used for textile fabrics, hats, slippers, rugs and various other articles. In Japan large quantities of this fibre — particularly the waste products — are used for the manufacture of paper.

Musa ensete from Ethiopia, *M. basjoo* from Japan and *M. superba* from China are the three ornamental bananas with coloured bracts and can be cultivated in green-houses.

M. Basjoo is a native of Ryukyu Archipelago between Japan and Taiwan. A sturdy plant, it was introduced to parts of Japan in 1881. It is still cultivated for the fibres from its leafstalk used in the manufacture of sail-cloth. Its fruits are not edible.

Bird of Paradise

Another member of Musaceae, *Strelitzia reginae* (Fig. 4.2.), commonly known as the 'Bird-of-Paradise' flower, is grown as an ornamental plant because of its banana-like foliage and very odd, showy flowers. There are about half-a-dozen species, all natives of Africa. The name *Strelitzia* was given after the wife of George III, Charlotte Sophia of the family Mecklenbury-Strelitz, who was a patron of botany.

Among the most beautiful birds of the world are the Birds-of-Paradise belonging to the family Paradisaeidae and confined to New Guinea and the nearby Islands, and some to the Moluccas and to eastern Australia. Though the females and the young ones are plainly coloured, the males are frequently rich in orange, yellow, green, blue, brown and red hues of many different shades.

The 'Bird-of-Paradise' flowers bear resemblance to these birds in their colour. These flowers of striking form are borne in scapes that are higher than the oblong paddle-like leaves which are about a foot long, stiff and borne on radical leaf-stalks two- or three-times as long as the blades. The spathe is about six inches long, nearly horizontal, purplish at the base, and commonly bears about six flowers that are orange and purplish in colour. Propagated by suckers and division of the rhizome, it is an important florist's crop in California and Hawaii.

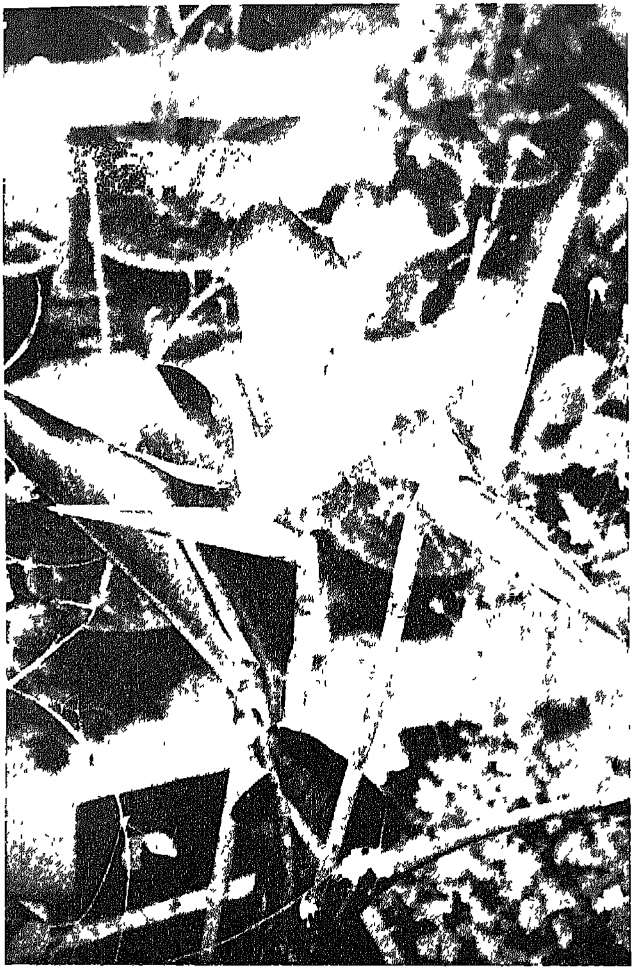


FIG. 4.2
Strelitzia reginae, inflorescence.

Wild Banana

The wild banana (*Heliconia,* Fig. 4.3) is yet another member of Musaceae and close to *Strelitzia* in flower structure. *Heliconia* grows

National Institute of Education

FIG. 4.3

'Wild Banana', *Heliconia bihai*, 'balister' (it is the national flower of Trinidad).

in the natural swampy areas of many American States (where banana is grown). These plants are almost 10 feet tall but rarely produce an erect stem or a trunk-like column from the slender long petioles of the waving leaves. Their floral bracts arise in an upright stalk, brilliant yellow and red bracts open to expose a few purple flowers that attract humming birds. *H. bihai*, the 'Bel' is the national flower of Trinidad.

Traveller's Tree

Yet another interesting plant of the banana family is the Traveller's Tree. It is called the 'Traveller's Palm' also and mistakenly thought to be a member of the Palm family. The size and shape of the leaves are, however, like those of banana plants. The Traveller's Tree grows up to a height of six metres and appears spectacular with its flattened fan-like leaves. The bases of the leaf stalks overlap each other in a highly symmetrical manner, right and left alternately. The leaf-bases are enlarged and collect large quantities of rain water so that when the leaf stalk is pierced from below the water flows out. This clear, sweet water is a blessing for the travellers who, it is said, have been saved from dying of thirst in the jungle, and hence the common name.

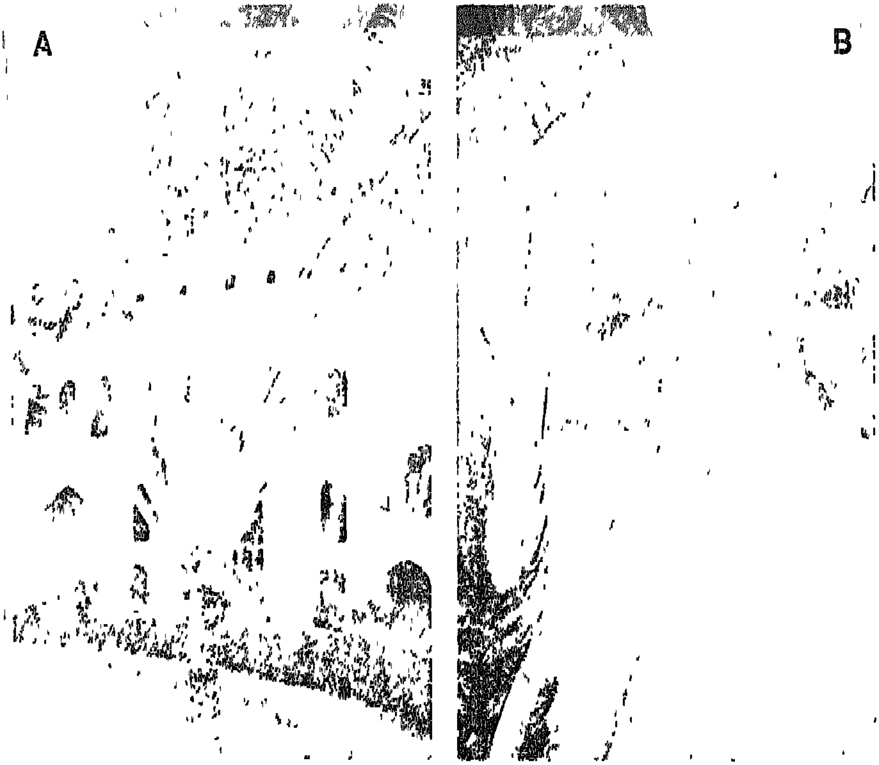


FIG. 4.4 A, B

The Traveller's Tree, *Ravenala madagascariensis*. A majestic tree at the Bara Imambara, Lucknow, Uttar Pradesh; note inflorescences in *B*. (*Courtesy:* A. J. Chakrabarty).

The botanical name of the plant is *Ravenala madagascariensis*, it being a native of Madagascar. It is often cultivated in many Indian gardens. Its mealy seeds are edible.

5

Some Exotic Plants

The Dragon's Tree

ONE of the mysterious trees of the world is the 'Dragon's Tree'. According to a folklore, a tree grows in the vicinity of the grave of the sea-demon 'Pau Tangalu'. From this tree blood oozes out drop by drop and falls on the grave of the Dragon. The story goes to say that if any husband has left his young wife, or any young man has forgotten his lady-love, the only way to win them over is to burn the 'Dragon's blood' on the window-sill and the fumes would reunite them. The only truth in this story is that there is a plant '*Dracaena draco*' which is the so-called 'Dragon's Blood Tree'. It is named so because the resin from the plant is red and when the stem is wounded, the resin drops like human blood.

The earliest information about this plant was given by a German artist, Martin Schongauer. He sketched this plant on a copper plaque during the fifteenth century. This world-famous piece of sketch was named The Flight into Egypt'. It depicts Mary and Joseph with child Jesus fleeing through a forest of *Dracaena* trees towards Egypt. However, the source of Schongauer's knowledge is not known, although his sketch of the 'Dragon's Tree' resembles the plant.

After a lapse of about 100 years, in 1569, Nicholas Monardes, a physician and historian from Seville, wrote about this plant in a book which was later translated into the English and named *Joyful Newes Out of the Newe Founde Worlde* by William Norton in 1577 (Saxena 1993).

In this book, Monardes wrote about his acquaintance with the Bishop of Cartagena (Spain). The Bishop had shown Monardes the 'fruit' of Dragon's Tree, on which the portrait of a dragon was carved. The carving was very realistic as if the dragon were alive and ready to attack any moment ! However, Monardes was clever enough to understand that it was not the fruit but a rounded structure made from the dark-red resin of a plant. In the earlier editions of this book, only a vivid description of the dreadful dragon carved on the fruit was given. In later editions, Monardes included the sketch also, as soon as printing of sketches was possible.

Botanically known as *Dracaena draco,* it belongs to the family Agavaceae. It has more than 80 species which are distributed in the African and Asian tropics. A detailed description of the plant was given by Alexander von Humbolt. He went to the Teneriffe Islands in 1799, and saw this plant before writing about it. These plants were 65–75 feet tall and about 45 feet in diameter. The local inhabitants of the Islands treated the tree as their 'saviour'.

In 1819, Berthelot visited Canary Islands and wrote a book on the birds, mammals and plants of that place. He, too, gave a vivid description of this mysterious tree. A large branch broke off during a cyclonic storm. The huge stem of the tree had a door fixed on it since it was hollow from inside. This space was so large that 10 to 12 persons could sit comfortably in it. A blood-red resin collects in the hollow of the trunk of the older trees. The natives of the Canary Islands used to collect this resin for various uses. They applied this resin on dead bodies to prevent them from decomposing over a long period of time. This process is, in a way, comparable to the making of mummies in Egypt.

The resin has medicinal value and is used as a mouthwash after mixing it with water or even as a toothpaste for brushing the teeth. It also acts as a good ointment for open wounds. Apart from these, the resin is also used for the preparation of varnish. In the eighteenth century, Italian violin-makers used this varnish because of its rich colour and staying quality. Due to these reasons, during the eighteenth century, the importance of 'Dragon's blood resin' increased and there was indiscriminate felling of the trees for collection of the resin. Some people even started collecting the resin from other plants that had red resin. One such plant was *Dracaena cinnabari* of Socotra Islands, and another *D. schizantha* from East Africa and southern Arabia. For adulteration, the resin of the African climber *Pergularia africana* was used.

The famous Dragon Tree of the Teneriffe was uprooted in a cyclone in 1868. Another tree on this island is known as the 'Millennium Tree'. It is said that the tree is 1,000 years old although scientists do not accept this age. The Dragon's Tree is indeed a 'mysterious' plant.

The Baobab

The East African Baobab or 'Monkey-Bread Tree' is *Adansonia digitata* (Fig. 5.1).

Springing from a seed which found its way into an old village well in Ramnagar tehsil of Barabanki district (Uttar Pradesh, India), the tree did not attract attention from passersby until its peculiar habit of hollowed out and bulged trunk coupled with bending down of the

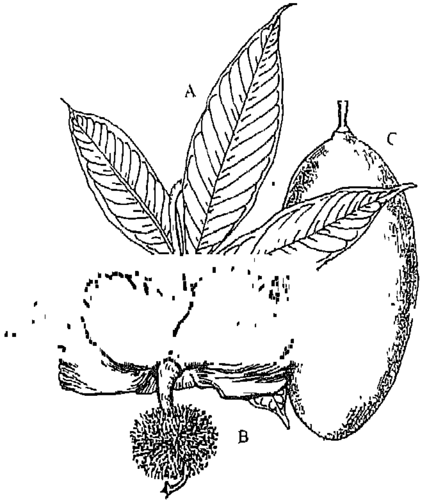


FIG. 5.1 A-C
Baobab, *Adansonia digitata. A* Leaf *B* Flower. *C* Fruit.

branches was exhibited. Yet another interesting feature is that the tree is leafless for the greater part of the year.

Although a stranger in this country, this particular specimen became an object of worship. The baobab grows extensively on the east coast of Africa and on the Island of Madagascar, where nine species occur. The Arabs discovered its valuable medicinal properties, and planted it wherever they migrated. It is a fairly well-known tree on the west coast of India, on the eastern coast in Chennai and Kolkata (Calcutta), and in Sri Lanka.

The age of a Baobab is not easy to determine. Its exceedingly soft wood does not form annual growth rings. However, it does grow for a thousand years.

The Baobab or 'Bottle Tree', *Adansonia gregorii* from Western Australia, is a tropical curiosity. It is quite distinct from its South African relatives. It is a water reservoir which can be tapped by thirsty travellers. *Ravenala madagascariensis* (called the 'Traveller's Tree') also accumulates water between the leaf sheaths (see Chapter 4).

Adansonia is a member of the family Bombacaceae. It is a tree with fantastic growth forms. The swollen bottle-shaped trunk tapers suddenly and sends out several thick, horizontal branches. Originally from Central Africa, it can thrive in dry desert areas. The presence of some very large and old trees has been reported from different parts of India. These might have been introduced a long time back. The leaves are digitately compound (Fig. 5.1 A), the whitish flowers are large, handsome, night-blooming and unpleasant-smelling (Fig, 5.1 B). Pollination is by bat. The large gourd-like fruit (Fig. 5.1 C) has a mealy edible pulp, sour to taste, but is relished by monkeys and hence the name 'Monkey-Bread Tree'. The hollowed shells of the fruit are used as floats by fishermen and as begging bowls by monks. Tribal Negroes of Africa follow a ritual — they suspend the bodies of distinguished persons in the hollows of old trunks of this tree. These bodies remain well-preserved without embalming.

The Breadfruit Tree

Captain Bligh's voyage to the Island of Tahiti and the Mutiny on the Bounty are well-known. The Bounty Trilogy — *Mutiny on the Bounty, Men Against the Sea* and *Pitcairn's Island* together make one of the greatest sea stories of all times Not all persons know the object of Bligh's expedition. In the eighteenth century, the British planters of the West Indies were growing sugarcane on vast areas. They brought Negro slaves from the western coast of Africa to work in the sugarcane fields and it became necessary to provide them with some cheap food. The answer : Breadfruit (*Artocarpus altilis*).

The first news of this fruit was brought to England by Captain William Dampier, an English navigator, explorer and pirate, on his return from Guam, one of the Ladrone Islands, in 1688. Captain James Cook, another English navigator, together with Sir Joseph Banks, and botanist Daniel Solander, explored the Pacific during 1770-80. They reported this fruit as a substitute for bread and one of the most useful vegetables in the world.

The Breadfruit tree (*Artocarpus altilis*) is large like its relative the Jackfruit (*A. heterophyllus*). It is a handsome tree, native to the Pacific Islands but now grown in Maharashtra, and along the eastern and western coasts of India. The large-sized fruits of this tree are of the size of a man's head and weigh up to 20 pounds. When ripe they are yellow and soft with starchy (carbohydrate content 26 per cent or more), seedless pulp, and with a pleasant odour and taste. It formed an important food for the natives of the South Pacific Islands as it was in season for eight months in a year. In 1787 one of the Secretaries of State in England wrote to the Admiralty:

> The Merchants and Planters interested in His Majesty's West India Possessions have represented that the Introduction of the Breadfruit Tree into the Islands in those Seas to constitute an Article of Food would be a very essential Benefit to the Inhabitants, and have humbly solicited that Measures may be taken for procuring some Trees of that Description... — to be transplanted in the said Islands ...,.
>
> I am in Consequence to signify to your Lordships His Majesty's Command that you do cause a Vessel of proper Class to be stored and Victualled for this Service...

Sir Joseph Banks, the botanist President of the Royal Society, took interest in the project. The ship 'Bounty' was ready under the captainship of Captain Bligh alongwith two horticulturists from the Kew Gardens to look after the plants when collected. The Bounty sailed from England on 15 October 1787. It was on 24 October 1788 that the Bounty reached Tahiti, after undergoing many hardships. Bligh exchanged the seeds of melon, cucumber and some other fruits for the saplings of Breadfruit from the native inhabitants of Tahiti. On 4 April 1789, the Bounty set sail for the West Indies with the precious cargo of young Breadfruit plants. The sailors, by this time, had married the native girls and were enjoying life and most of them were unwilling to go back. Moreover, Captain Bligh did not treat his crew well. Very often he would impose stern punishment for comparatively small offences. Also, his selection of the crew was not ideal. A large number of them were carefree and irresponsible and would rather lead a life of ease and comfort than face the dangers of sea travel.

The dissatisfied men did not keep quiet for long. The famous 'Mutiny on the Bounty' broke out on 28 April 1789. Bligh and a few of his loyal followers were pushed into a small boat and left to drift in the open ocean. The precious Breadfruit trees were thrown into the ocean. However, luck was on their side and Bligh with 18 others made one of the most remarkable open-boat voyages in the history of navigation. They reached the Island of Tofoa but the inhabitants were not friendly and so they moved on to the Island of Timor. And from here a British ship took them to England.

Sir Joseph Banks persuaded the British Government to send Bligh on a second voyage to Tahiti in December 1792. This time with better luck and better crew members, he reached Tahiti on 8 April 1793, in his vessel 'Providence'. He left this Island on 18 July the same year, after procuring 2,126 potted Breadfruit plants and about 580 other plants. About 700 of these survived and were delivered in the Islands of St Helena, St Vincent and Jamaica.

An original Breadfruit tree planted by William Bligh in 1793 still stands in the Botanical Gardens in St Vincent Island. The Breadfruit trees flourished in the British colonies and produced bountiful crop. The irony of the entire mission involving a number of dangerous voyages and so many lives (because most of the Mutineers had met with a violent end on the strife-torn Pitcairn Island), was that the Negro slaves found it insipid to their palates. They preferred to eat the more familiar yams and plantains but not this new fruit in any form — boiled, baked or fried. For 50 years it was primarily fed to pigs and only by the middle of the nineteenth century did it become widely accepted as human food.

A Breadfruit tree was introduced in the Victoria Gardens, Bombay, and is a great attraction.

The Spanish Moss

The Spanish Moss is botanically known as *Tillandsia usneoides*, an angiosperm, and belongs to the family Bromeliaceae of the monocots. It is the largest genus of this family with about 350 spp. and occurs in southern United States of America, Chile and Argentina. Although commonly known as 'Spanish Moss', it is neither Moss nor Spanish.

Tillandsias have both terrestrial and epiphytic forms. Its tough leaves are arranged in rosettes in some species, spiral in some others, or in two vertical rows running up the stem in other species.

Tillandsia usneoides (Spanish Moss) grows as epiphytes on the bark of trees. This American epiphyte covers the trees much the same way as does the lichen *Usnea barbata*, in temperate zones. Hence, the name *usneoides*. It develops long, rope-like, thin twisted branches. The leaves are small and collect water in their funnel-like sheaths. The branches and leaves are covered with furry scales. The flowers are too small to be

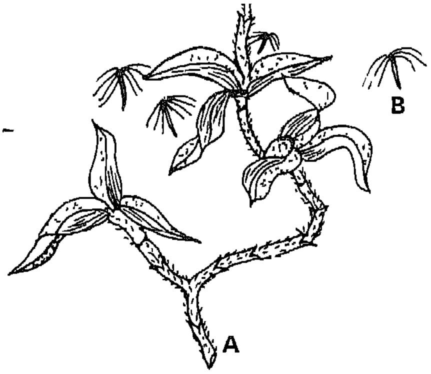


FIG 5 2 A, B
Spanish Moss, *Tillandsia usneoides*.
A Rootless epiphyte of the American tropics. *B* Seed.

noticed; the fruits are capsules which burst open to release the hairy seeds (Fig. 5.2 A, B). The hairy coat of the seeds, first functions as wings and the minute seeds are carried far away by the wind. If these seeds become stranded anywhere on the bark of a tree-trunk, the hair cling firmly and bring the seeds in contact with the substratum so that they can germinate and establish themselves.

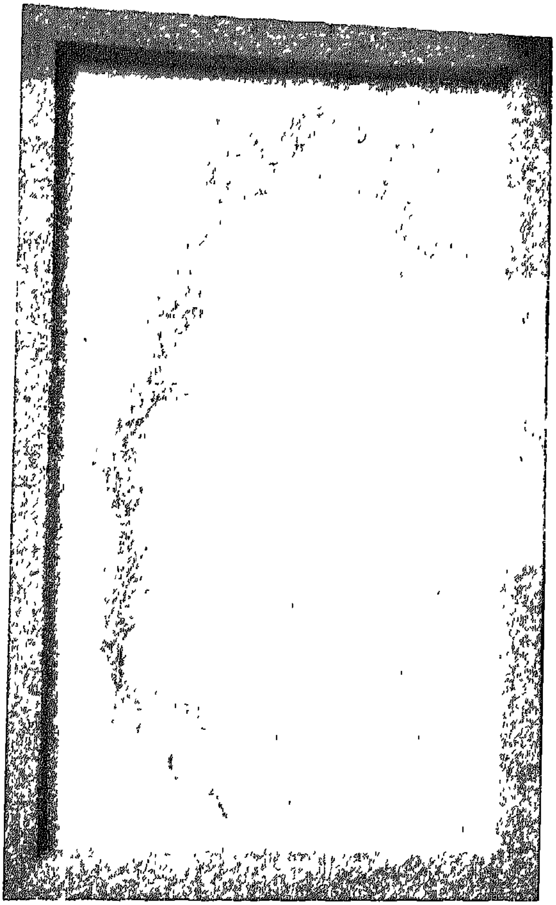


FIG. 5.3

Tillandsia usneoides, a herbarium specimen collected from Glasgow Botanical Garden, Glasgow (UK).

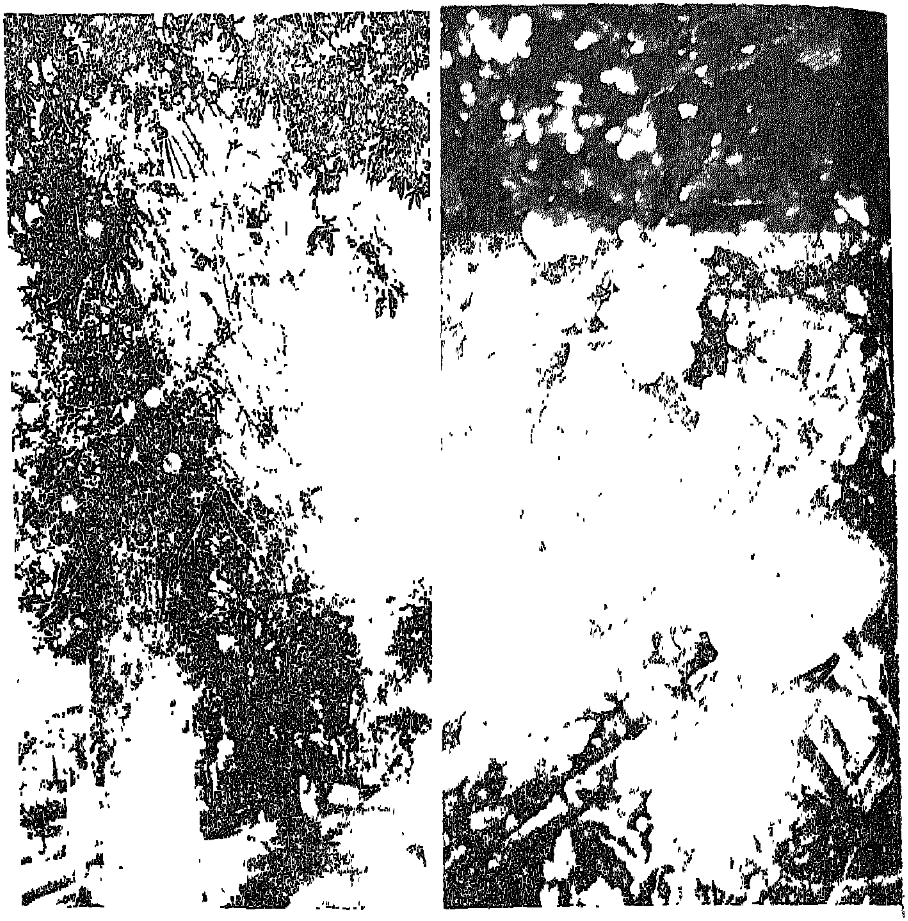
The Spanish Moss plants hang in long festoons (Fig. 5.3) from trees but avoid the rain-forest proper. In moist areas some species grow on telegraph wires and poles, and hence the name 'Telegraph Plant'. The soft elastic stem is dried and used as stuffing or packing material under the name 'Louisiana Moss'. These epiphytic plants do not have any root and survive on dust, dew and occasional rain. The furry scales on the branches and leaves help to absorb moisture from any source and transmit it to the tissue beneath.

The Cannon-ball Tree

The Cannon-ball tree is a native of tropical South America (French Guiana) and the West Indies. In addition to numerous indigenous trees of our own, quite a few trees have been introduced into our country from other far and near countries. One such tree is the Cannon-ball tree, botanically known as *Couroupita guianensis* (Fig. 5.4 A, B). These are lofty trees grown mostly near Shiva temples in South India and in West Bengal. The flowers are borne on older woody branches and are multicoloured (a tinge of white, yellow and pinkish-purple colour). The fertile stamens, with a common stalk, arise from one side of the flower and curve backwards over the ovary, style and stigma like the hood of a naga (snake). This is obviously to assist in pollination. But, the superstitious mind of the devotee can imagine a many-headed cobra bending over the shiva-lingam as if to protect it. Hence, the common vernacular name, 'Naga-linga Pushpam'. Its flowers are offered in worship to the sacred 'lingam'. Some of the temples where its flowers are offered are the Meenakshi temple, Madurai; Nataraja temple, Chidambaram; Sri Nellaiyappar temple, Tirunelveli; Jambu-Keshvara temple, Tiruchirapalli, all in Tamil Nadu, and Virupaksha temple, Hampi in Karnataka.

As the staminal band formed by the fused stamens bends over the pistil which looks like the 'lingam', one has to lift the staminal band to observe the 'lingam'-like pistil.

The fruits ripen in eight or nine months, are dark-brown, very large and globular. These fruits are borne on the woody branches and are comparable with the cannon-balls of olden days, in both size and



A FIG. 5.4 A, B B

Cannon-ball tree, *Couroupita guianensis*. *A* Tree bearing flowers and fruits. *B* Flowers in bunches.

colour. The fruits burst open with a 'loud' sound. The pulp inside has an unpleasant odour and has numerous seeds. The timber is useful. It is a tall, deciduous, soft-wooded, erect tree up to 20 metres high, with a large spreading crown and dark-brown trunk.

6

The Misfits

THE gymnosperms are easily recognized (with a few exceptions) by the presence of male and female cones. In many species these are large, prominent and beautiful — objects of admiration and appreciation.

The gymnosperms include the tall and mighty conifers of the temperate region mostly with needle-like leaves; shorter cycads from the tropics with palm-like foliage and large cones, and a third group of two very odd plants. These are so highly-evolved that they have some gymnospermous and some angiospermous features. Wilkins (1988) correctly says, "It is a group that has clearly evolved or was created, especially to defeat a neat classification of the plant kingdom." This group includes the beautiful *Ginkgo* (Fig. 6.1 A-C) with fan-shaped leaves, and the ragged *Welwitschia* (Fig. 6.3) which tries to achieve the impossible as it grows only in the hottest and the driest desertland of south-west Africa.

Because of their unusual features, not found in any other plant-group, we have called them the 'misfits'.

Two other misfits included in this chapter are angiospermous

— *Idria* and *Fouquieria.* There is much controversy regarding their systematic position.

Maiden-hair Tree

The beautiful maiden-hair tree, botanically called *Ginkgo*, is rather like the giant Panda — more often seen in captivity than in the wild.

Spreading its roots under the cement sidewalks and its leaves into the shade of tall buildings (as in Tokyo, Japan), the maiden-hair tree has become familiar to the city people as one of the few trees that can survive despite soot and automobile exhausts. It is the only survivor of a once widespread but now extinct group of trees and is, therefore, called a 'living fossil'. Before the last ice age (10,000 years ago) of the earth's history, it was widely distributed and the fossil *Ginkgo* leaves look almost exactly like the leaves from the living trees. For about 150 million years, the maiden-hair tree has remained virtually unchanged despite the rise and fall of dinosaurs and later the arrival of mankind.

The sturdy trunks of *Ginkgo*, clad in grey bark with irregular furrows, rise one after another along the streets and avenues.

Ginkgo was probably somewhat rare as far back as the tenth century. The priests in China started growing these beautiful trees in the compound of their temples. From China this practice spread to Japan, and here the European travellers gazed at this wonder of the plant world. The Japanese called it '*Gingko*' in their native language. But by the time the seeds of the orient germinated in occidental soil, the name changed to '*Ginkgo*' and this is its scientific name also.

It is not known to be a native member of any natural forest in any part of the world. Of course, there are a few *Ginkgo* plants in the thick forests of the upper Yangtse Valley in Western China; probably these are the escapes from cultivation. These straight trees are about 80 feet tall. The branches rise steeply and bear short spurs from which the leaves grow in clusters. It is a deciduous tree unlike majority of the conifers. Early in spring the fresh foliage develops. Each leaf looks like a Japanese folding fan (Fig. 6.1 A). They are thin, beautiful, and bright-green which become somewhat dull during summer.

The beautiful venation resembles those of Maiden-hair fern

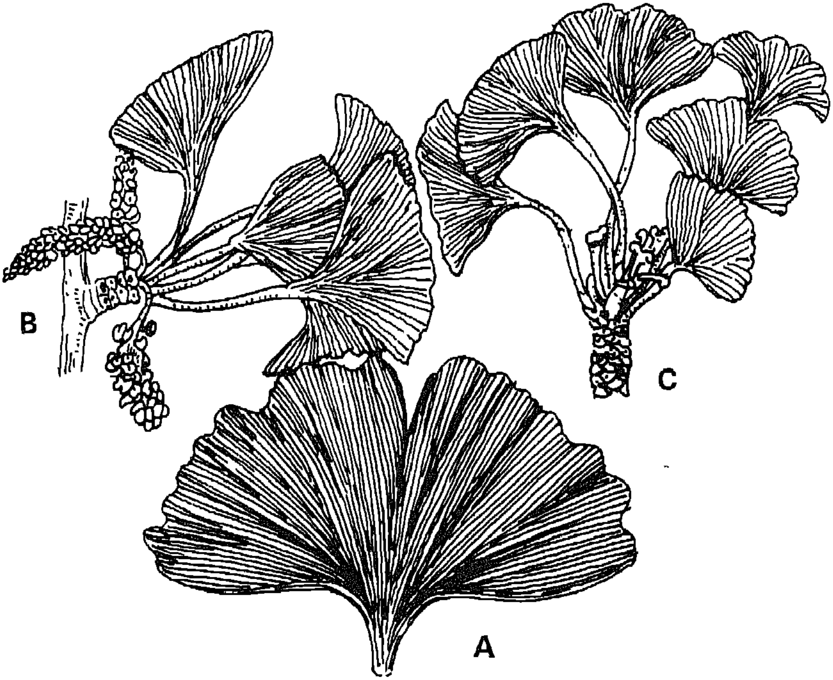


FIG 6.1 A–C
Maiden-hair tree, *Ginkgo biloba*. Leaf *(A)*.
Male *(B)* and female *(C)* cones.

(*Adiantum venustum*) grown in gardens. Many of the leaves of *Ginkgo* are deeply-notched near the middle and hence the specific epithet '*biloba*'. In autumn the leaves turn golden-yellow and shed.

Male and female cones develop on separate trees (Fig. 6.1 B, C). At the Innsbruck (Austria) Botanical Garden, a female tree has been grafted with a male branch so that ovules are borne in plenty.

When the ovules (Fig. 6.2) ripen they fall off, each covered with a fleshy seed-coat. Many believe that the fleshy coat is poisonous even to the touch, and it decomposes emanating a nauseating smell. Nevertheless, the Orientals have celebrated *Ginkgo* seeds in poetry as "Silver Apricots", referring to the waxy bloom that covers them when they are ripe. The seeds are gathered, the fleshy seed-

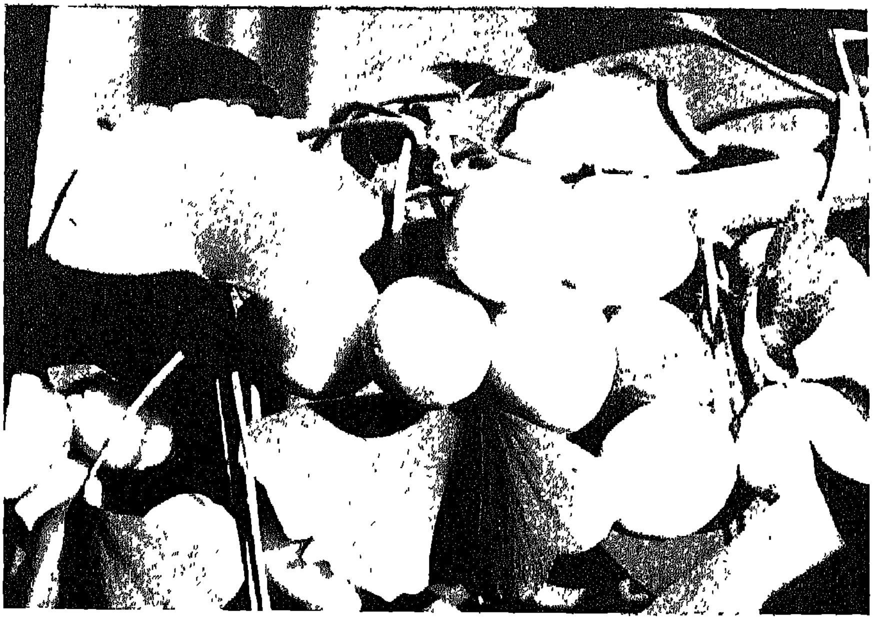


FIG 6 2

Ginkgo biloba, twig bearing the ovules (seeds).

coat removed by fermentation, boiled and dried or roasted to remove any poisonous substance that remains, and eaten as the precious 'ginkgo nuts'. In Japan the green ovules are fried and eaten as a delicacy.

The wood is light and yellow. It is said to be used for chess-boards, chess pawns, chopping blocks and as firewood.

In the Tokyo Botanical Garden stands a historic, majestic male tree. In 1896 Hirase discovered the first motile spermatozoid (from the pollen grain/tube) in seed plants.

The Two-leaved Curio

The two-leaved curio, *Welwitschia* (Fig. 6.3) is a bizarre plant (gymnosperm), native of south-west Africa. It comprises a very deep-seated combined stem-and-root, shaped like a very long inverted cone or a large woody parsnip. The top of the stem is concave, woody and disc-shaped. Despite living for ca. 2,000 years, the plant produces only two leaves which spread over the hot sand of the desert.

In older leaves, the soft, green portion at the distal end degenerates and the veins persist so that the distal end simulates a 'broom'. This is a continuous process.

Sometimes, however, it shows blue-green leaves, light-red cones dotted with green on the female plants, and brilliant orange-red male cones on the male plants.

The secret of longevity of these leaves is that they grow and elongate continuously from a meristem at their base. These plants grow and survive in an area where it may rain only once in five years.

An Austrian botanist, Frederic Welwitsch, came across this unusual plant in 1859 in the deserts of Angola. The second plant was noted by another adventurer, Thomas Baines, in 1861, about 500 miles away

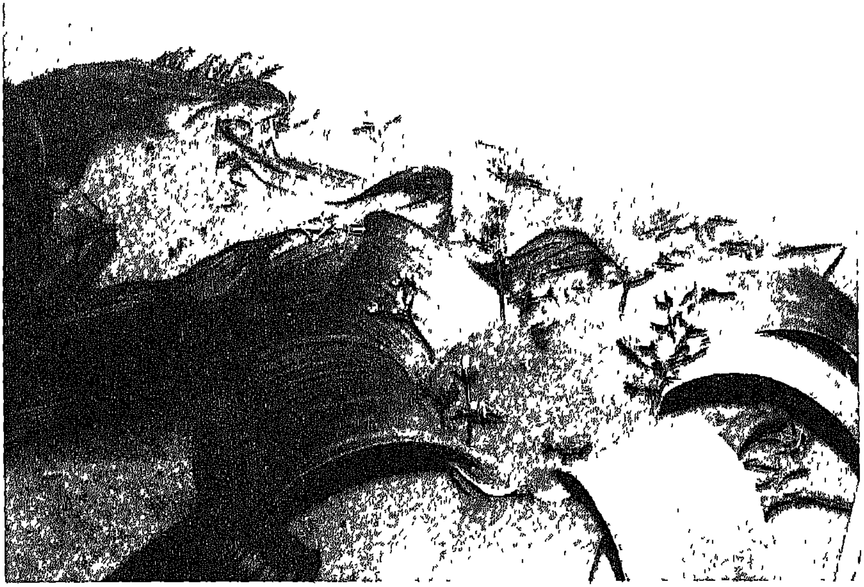


FIG 6.3
The two-leaved wonder, *Welwitschia mirabilis.*

in the basin of a dried up river. As Baines was an artist also, he sketched the plant and published it. Soon, the world was aware of it and in honour of Welwitsch, it was named *Welwitschia* by Sir William Hooker.

The plants have been introduced in numerous Botanical Gardens. There are some specimens in the botanical gardens at Kew, Montreal, the University of Stellenbosch (South Africa), and many others. Some specimens are also growing at the National Botanical Research Institute, Lucknow (India).

It is not a rare plant, but very few flourish in captivity, and are carefully protected. South-west African ten shilling postal stamps commemorate *Welwitschia.*

Welwitschias look more like a tree that has been driven underground to protect itself from the scorching heat and sandstorms of the deserts. The taproot is like a tree-trunk and can go down 60 feet in search of water under the desert sand. The roots of the plants at Kew and at Stellenbosch grow deep down in 'drainpipes' up to the water table (0. Leese and Margarate Leese 1959).

The Candle Wood

The Candle Wood, 'Ocotillo' (little pine) or 'Coachwhip' plants (botanically *Fouquieria splendens,* Fig. 6.4) grow in the desert areas from California to western Texas. The plant has a trunk only about one foot high and large wand-like branches as much as 20 feet long and one to 2.5 inches in diameter. These branches are covered with numerous short, thorny projections, formed from the petiole and midrib of a leaf at every node. The thorny appearance gives the plant another name, 'Cat's Claw'.

The rains give the plants a magic-touch and leaf clusters of bright-green colour appear in the axils of the spines. If the season is suitable, the terminal racemose clusters of bright orange or crimson flowers also appear. Because of these swinging spikes of attractive flowers, the plant is called 'Banner Cactus'. The thorny projections save the plant from herbivorous animals.

The dry, woody stems collected during the dry season can be used like a candle by burning them from one end.

Fouquieria (family Fouquieriaceae) is a rather unusual plant with no close relative. It contains a large number of chemicals like iridoids, ellagic acid, waxes, triterpenes and triterpene saponins (Hegnauer 1966), steroidal saponins and tannins (Gibbs 1974), coumarins, caffeic acid, quercetin, kaemperol, leucocyanidin and other phenolic compounds.

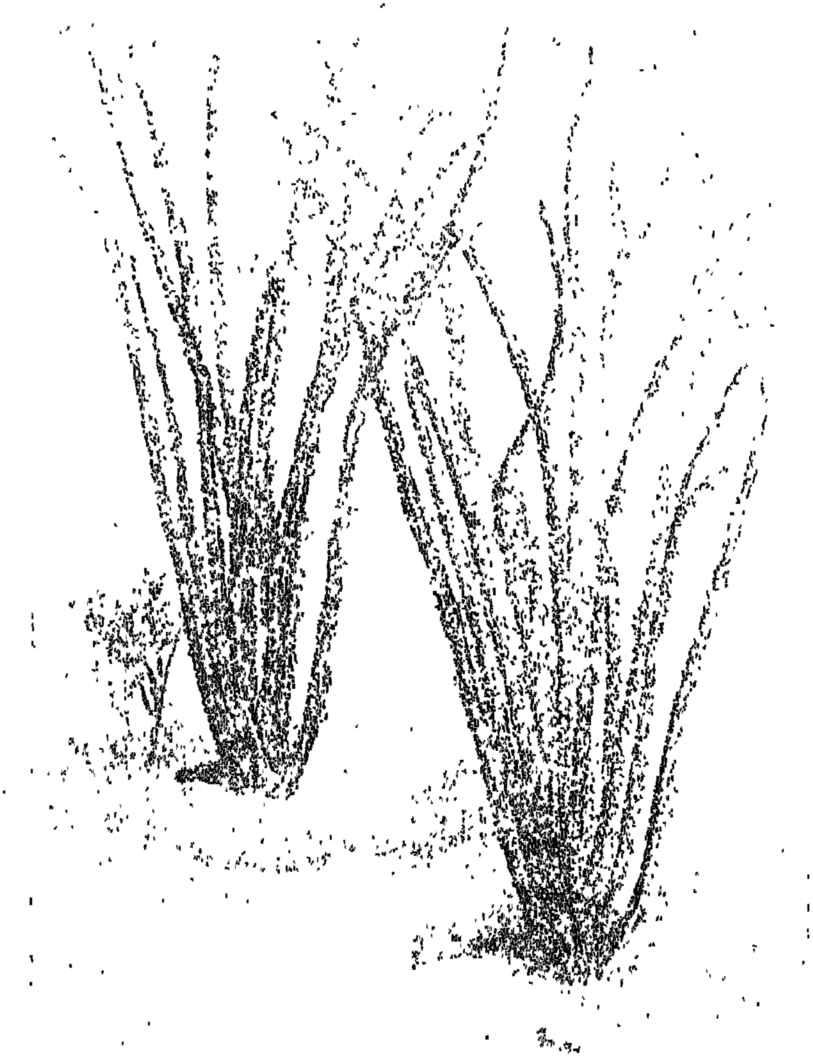


FIG. 6.4

Coachwhip plant, *Fouquieria splendens* of the Mexican deserts.

The Boojum Tree

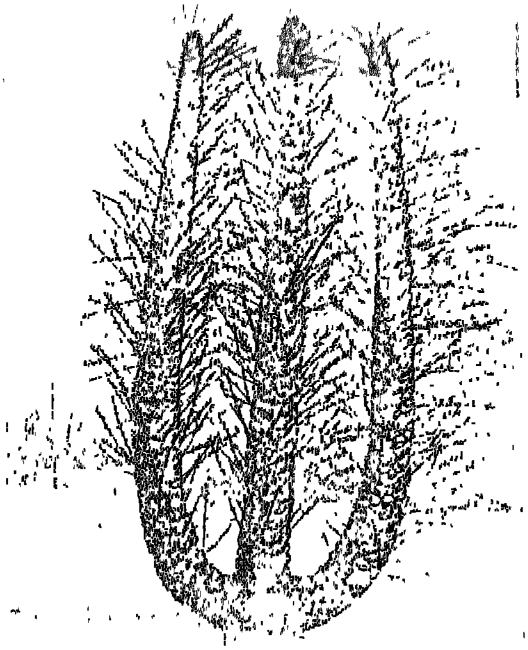


FIG 6 5
'Boojum' tree, *Idria columnaris*, branchless and leafless tree of Baja, California.

Another member of the family Fouquieriaceae is *Idria columnaris* (Fig. 6.5) from the deserts of Baja, California and western Sonora in Mexico, known as the 'Boojum Tree' or 'Cirio' (a waxen taper) and is often cultivated as a curiosity. This weird tree is like a giant carrot turned upside down, 10 to 30 feet high with only a few small delicate twigs appearing at the apex of the almost white or greenish-white trunk. After the rains, these branches produce new leaves and clusters of white flowers. The large swollen trunk stores water and being green undergoes photosynthesis in the presence of sunlight. After the water has been utilized, the Boojum tree regains its original slender form, and sometimes bends, so much as to form an arch.

Neither of the plants, i.e. *Fouquieria spendens* nor *Idria columnaris*, has any economic importance, but their unusual forms make them vegetable curiosities.

7

The King Cotton and the Red Silk-cotton

The dominating fibre needs of the world are taken care of by the cotton plant. In addition, it also provides human food (edible oil) and livestock feed (oil-cake). Although the use of the seed and its products is quite recent, the use of cotton fibres is ancient. Cotton fabric has been one of the most interesting finds relating to the ancient civilization of the Indus Valley (ca 3,000 B.C.). The spun cotton yarns from the excavations of the city of Mohen-jo-Daro (now in Pakistan) speak of a high degree of skill in the art of spinning and weaving. Cotton is mentioned in a Rig-Veda hymn, fifteen centuries before Chirst.

The Greek historian and traveller, Herodotus, wrote in 445 B.C.: "There are trees growing in India, the fruit of which has a wool exceeding in beauty and goodness the wool of sheep. The Indians make their clothes of this tree wool." Theophrastus (372-287 B.C.) gave a better account of the plant : "The trees from which the Indians make a cloth have a leaf like that of the black mulberry, but the whole plant resembles the dog-rose (*Ipomoea* sp.). They set them in plains arranged in rows so as to look like vines at a distance." Cotton, the Hebrew '*Karpus*', is mentioned only once in the Bible. Presumably, it was not grown in Israel in the early Biblical period but cultivated in the last century B.C. It was called 'tzemergefer' (vine wood) because its leaves resemble those of a true vine. In 323 B.C., Alexander the Great brought cotton to Asia Minor from India. In 300 B.C., cotton cultivation was established in Egypt, and the Greeks grew it as a decorative garden plant. In A.D. 600, cotton reached China, and in A.D. 789, Japan, due to a Chinese shipwreck on Japanese coast. The ship was laden with cotton seeds. In A.D. 912 the first cotton plantation was established in Spain.

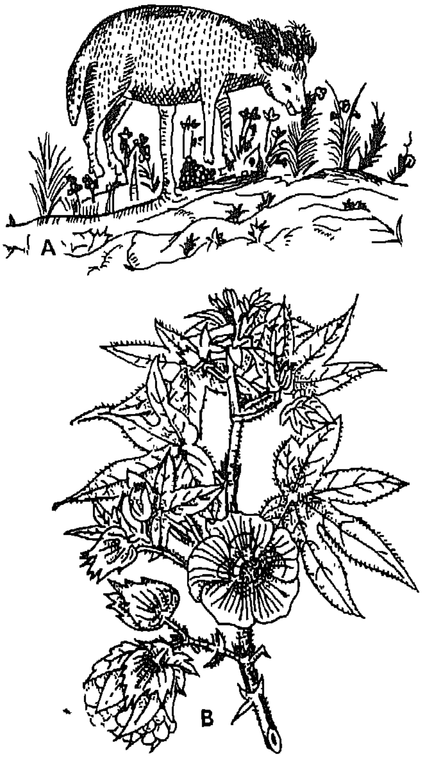


FIG. 7.1 A, B

Cotton. *A* 'Vegetable Lamb Tree' (the imagination of an unknown artist). *B* Twig of cotton plant, *Gossypium*, with flower and fruit.

During the Dark Ages (ca. A.D. 200-1,200), the whole of Europe was completely ignorant of anything happening around the world. The travellers returning from Samarkand reported the existence of 'Vegetable Lamb Tree' (Fig. 7.1 A) in Tartary and the lands beyond Catha (China). This was called 'barometz' by the natives and its fruits resembled a lamb. The hanging woolly heads of these 'lamb-fruits' were believed to feed on surrounding grass. Indian fabrics, spun and woven from these 'lamb-heads', was one of the precious items brought to the West by the Arab merchants. The Arabs called it 'Al-quton' which changed to Spanish 'Algodon', French 'Coton', German 'Kattum' and finally to the English 'Cotton'.

For 3,000 years India remained the centre of the cotton industry of the Old World. Marco Polo wrote that the Coromandel coast produced the "finest and most beautiful cottons in the world." Dacca (now Dhaka in Bangladesh) muslins became famous because of their soft, fine and beautiful texture. When such muslin was laid on grass to bleach and the dew fell on it, it was no longer visible. A whole five yards saree of this material could be pulled through a (finger) ring.

The cotton trade between Europe and India almost came to a halt during the latter part of the fifteenth century as, due to political reasons, the overland caravan route was almost closed. But as soon as the sea-route to India was discovered, the Portuguese started the trade again, in full swing. The fine, light, washable, cheap and richly-coloured 'chintzes' and 'calicos' could not be duplicated in Europe and there was a large demand for these products. With the help of the British East India Company, European markets were flooded with cotton goods from India. The new development did not make the people who were interested in woollens happy. Hundreds of voices were raised in favour of English wool and Acts of Parliament were passed by both Queen Anne as well as George I prohibiting the use of Indian cottons and silks. In 1701 the import of Indian muslins was also prohibited. However, the prohibition only made way for smugglers. Cotton is an ideal material to wear next to the skin (understood only after some years). In fact, Britain also started the manufacture of cotton cloth during 1750-1914. Lancashire became the best producer of cotton goods in the world. At almost the same time, the Indian textile industry was losing ground, more so because of the British East India Company. To stop the weaving of the best quality muslins, the thumbs of many weavers were chopped off by the British oppressors.

On the other side of the globe, cotton was cultivated by the ancestors of the Aztecs, Mayas, Columbians and Incas, centuries before the discovery of America by the white man. Cotton has been discovered in pre-historic Pueblo ruins in Arizona, and cotton grave-cloths from pre-Inca Peru still exist. The spinning of cotton for nets and fishing lines was apparently a more ancient practice than weaving of cloth in Peru and the Carribbean. In 1492, when Columbus reached West Indies, he noticed that the local inhabitants wore colourful cotton robes. The natives even brought bales of cotton yarn to his ship for barter; and this was one of the reasons for his belief that he had reached India.

The introduction of cotton into the south-eastern area of the United States of America came much later. In 1621, some seeds were planted on an experimental basis. The coarse cloth that was manufactured by the end of the century, was mostly used by the poorer classes in the southern states. In the eighteenth century also, cotton was not an important agricultural crop in North American colonies. Spanish West Indies and Portuguese Brazil were the leading producers and exporters. With Whitney's invention of saw-toothed cotton gin (a simple machine to separate the seeds from the hairy cover), American cotton cultivation got a boost. As a matter of fact, a good proportion of the cotton for Lancashire mills was sent from the southern states of the United States of America.

Though there are many synthetic fibres in use these days, cotton still remains supreme because of its softness, washable qualities and good texture.

Cotton is obtained from different species of the genus *Gossypium*: *G herbaceum* (of the Old World) and *G. arboreum* (of the New World). The plants are shrubs of medium height (Fig. 7.1 B) and bear numerous branches and vine-like leaves. The flowers are yellow, lemon-yellow, pink or dark-pink; fruits are capsules which burst open into white floss. Cotton is obtained from this fine fibrous hair that occurs on the seed surface. Long, flattened, tubular hair with twists is the 'lint' or 'staple' and the small hairy covering on the seeds is the 'fuzz'.

Every part of the plant is commercially useful. The stalks contain a fibre used in the paper industry or as fuel. The roots contain a crude drug (Johri and Srivastava 1978). Staple cotton — the long fibres from the seed surface — are utilized in the manufacture of textiles, rubber-tyre, fabrics and other woven products. 'Linters' or 'fuzz' or the short hair adhered to the seed surface are used as source of cellulose suitable for the manufacture of superior acetates and viscose rayons, cellulose ethers and esters, nitrocellulose lacquers and as stuffing material. Hull — the outer covering of the seed — is used as cattle-feed, fertilizer and soil conditioner, fillers in plastics, manufacture of insulating materials and many others (Singh et al. 1990). Cotton seed oil is edible and is used in the manufacture of 'vanaspati', soaps, paints and varnishes, toileteries, in the leather industry, and as a lubricant. Cotton-seed cake is used as fertilizer and as cattle-feed. Cotton-seed meal is protein rich and it has been possible to use it as a food for human consumption (Singh et al. 1990).

Red Silk-cotton

Though named 'silk-cotton', it is neither silk nor cotton. This tree, *Bombax ceiba* (synonym — *Salmalia malabarica*, Fig. 7.2), bears fibres

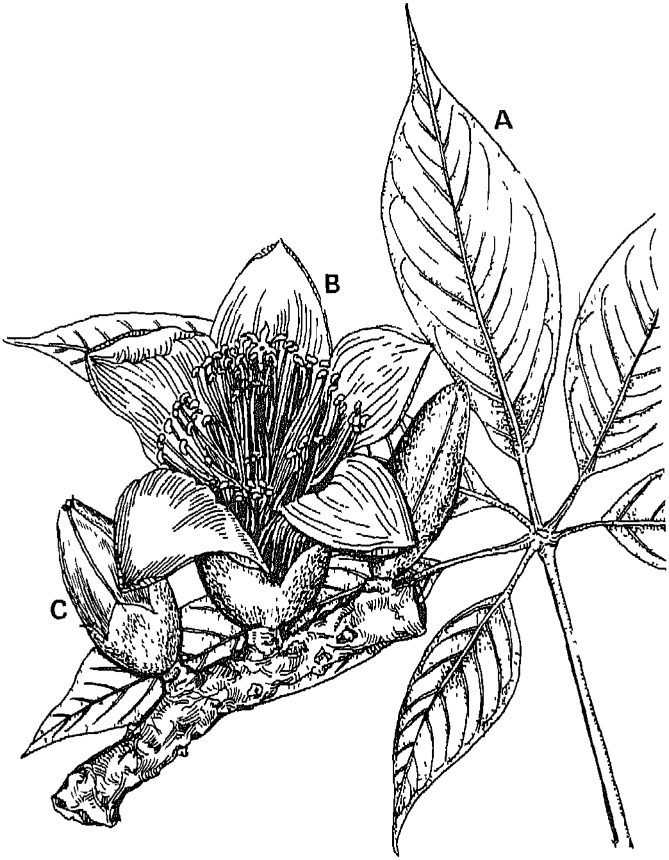


FIG. 7.2

Red silk-cotton, *Bombax ceiba*. *A* Leaf. *B* Flower. *C* Fruit.

like cotton. The fibres are silky, and hence the name 'silk-cotton'. The botanical name *Salmalia* is the Latinized name from the original Sanskrit name '*Shalmali*'; *malabarica* denotes that it is from the part of peninsular India known as Malabar. The valid name *Bombax* is after '*Bombux*' which in Greek means silkworm.

The tree, when in flower, is visited by numerous birds who feed on the nectar. It is often opined that Brahma, the Creator of the World, rested under this tree when He was tired.

The tree has prominent, sturdy, short barbs all over the stem, and therefore nobody can climb this tree.

According to an Oriyan folklore, the King of Judagarh (Orissa) had two wives but did not have any child. He loved his wives and did not want to marry again for the sake of an heir to the throne. Instead, he promised half of his kingdom to the person who could cure his wives of infertility. In a nearby village lived a 'holy man', Kaliya Dano, who was actually a demon in the habit of eating human beings. Kaliya Dano took up the challenge of curing the wives of the King of Judagarh. The two ill-fated women were sent to him for treatment, and Kaliya Dano had a hearty meal of them.

The King was anxious to know about the outcome of the treatment, and sent messages to Kaliya Dano, who did not answer the King's men pretending that he was in meditation. After a long wait, the King himself came to Kaliya Dano to take his wives back. When the demon saw him approach the village, he ran away and entered the nearby forest. On entering the demon's hut, the King understood what had happened, and in a rage he pursued the demon in the forest. To save himself, the demon climbed a tall tree, pulled out all his sharp teeth and planted them on the trunk of the tree. And to this day we see the barbs strongly embedded in the stem of the tree (on which the demon remained perched).

Yet another story brings out another fact — why the Shalmali tree loses all its leaves at a time. Once upon a time there was a large Shalmali tree growing in the cradle of the Himalayas. The evergreen tree was loved and praised by everyone who sat in its shade anytime of the year.

In Hindu mythology, there is one character, Narada Muni, who loves to create confusion and misunderstanding amongst Gods and mortals alike. One fine day when Narada was resting under the shade of a Shalmali tree, he observed that this tree never lost a leaf. He addressed the tree and teased it saying that Pavana, the God of Wind, had befriended him so much that he was not affected by his force. Too much praise had made Shalmali arrogant. The tree answered that it did not bother so much about Pavana's friendship or protection, and Pavana was unsuccessful in his attempts to make it leafless because Shalmali was strong enough to resist him.

Narada wanted nothing else. This statement from Shalmali was enough to create misunderstanding between Pavana and Shalmali. As expected, Pavana was very annoyed and immediately went to Shalmali. He told the tree that as Brahma, the Creator (who was his grandfather), once rested under its shade, he did not want to harm him. But that did not permit Shalmali to insult him and, as punishment, its leaves would not grow again. Shalmali was not perturbed and answered back in equal rage that it was not afraid of Pavana.

But when Pavana left, the tree realized its mistake and decided to punish itself by inflicting self injuries. It shed all its leaves, and broke most of the branches. Pavana came back with his army of rain, sleet, hail, snow, thunder and lightning, but what did he see? The arrogant Shalmali was no more there, instead it was a humble Shalmali, head-bent and without the glory of its green crown. Pavana was not angry with the tree any more. Shalmali again regained its beautiful crown of glory, but to remind itself of this lesson, it voluntarily drops all its leaves once a year.

The lofty, wide-spreading, deciduous tree, 'semal', is very common all over India. It looks particularly attractive when the leafless branches burst into crimson, orange, dark pink or yellow flowers. Birds feed on the nectar and therefore the ground below the tree remains strewn with flowers. The fruits are more or less egg-shaped, brown and burst open when mature. Inside there are black seeds embedded in white, fluffy hair which develop from the inner wall of the fruit. This is the red silk-cotton fibre used for stuffing pillows. The timber is used in making matchsticks and packing cases.

●

8

Wealth of the Forest

VARIOUS trees have been mentioned in our ancient literature — be it Valmiki's *Ramayana*, or Kalidasa's *Ritusamhara* and *Abhigyana Shakuntalam*. Some of the trees are mythical, some others have religious importance. To the Buddhists, the Bodhi tree, Pipal, is the symbol of knowledge because under this tree, at Gaya, Gautama Buddha attained enlightment (see Chapter 2).

In this chapter, we discuss some important timber trees (Teak, Ebony and Rosewoods), trees of medicinal value (Margosa), and trees yielding essential oil (Sandalwood).

Man's life is woven around trees from time immemorial. Trees have given him shelter against sun and rain, fuel to cook his food, and wood to build his house, fruits and seeds to eat, and even clothing, and medicine for ailments.

When Rama, Sita and Lakshman remained in exile for 14 years, they had to cast off their royal clothing, and what do you think they wore? They wore 'Valkal', i.e. the bark of 'nyagrodh' or the banyan tree (see Fig 2.1). The pipal (*Ficus religiosa*, Fig. 2.5) and banyan (*F. benghalensis*) trees, particularly in villages, are still the focal points for important meetings and gatherings. Our countrysides are rich in varied types of trees—the neem (*Azadirachta indica*), babul (*Acacia* *nilotica*), tamarind (*Tamarindus indica*), sal (*Shorea robusta*), palash (*Butea monosperma*), mango (*Mangifera indica*) are only some of them. People residing in cities are not so fortunate as to live in such peaceful, cool surroundings. The only way the urban population can enjoy the beauty and usefulness of trees is by growing them as avenue trees along the roadsides. They not only help in removing the barrenness, but also help in controlling pollution.

Teak

An arrogant rich merchant had seven daughters. One day he asked them whose wealth and fortune was keeping them happy and alive? One by one, his six daughters answered that it was their father's fortune. However, the seventh daughter answered differently. According to her, it was her own good fortune which kept her happy and alive. The angry father sent her away into the dense forest to see how fortunate she was. She was allowed to take her old nurse and her sewing needles and thread. The young and the old were both afraid as the wild beasts were about to come out with nightfall. They huddled together under a large Teak tree. The tree took pity on them and split its trunk in two halves so that the two women could take refuge in the hollow and then closed back to its original shape. At night, the wild beasts came out and attacked the tree in all fury as they could smell human flesh

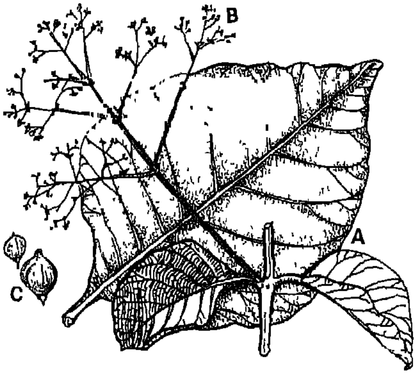


FIG. 8.1
Teakwood, *Tectona grandis*.
A Leaves. *B* Inflorescences. *C* Fruits.

inside its trunk. The tree withstood all the torture throughout the night and at daybreak let the two women out. The girl felt sorry for the tree and applied some medication so that it would feel better. The tree then asked the girl to sell some of her needles and thread in the nearby city and buy some puffed rice for eating. When the nurse got it, the tree advised them to eat only half of the puffed rice and strew the rest on the bank of the river. At nighfall, the Teak tree again gave them protection. In the morning, they were amazed to see a large number of peacock feathers strewn on the river-bank. The peacocks had visited the river-bank at night and at the sight of the puffed rice they went 'mad' and jostled around to eat it, and this way they lost some of their tail feathers.

The tree now asked the girl to make a fan with the feathers and send it to the king. The prince was enchanted to see the fan and bought it. With this money more puffed rice was purchased, and again the peacocks were lured with it and they again left some feathers. This continued for sometime and everyone in the king's court was buying the beautiful fans. The prince asked about the maker of the fans everytime he met the old nurse and became more and more curious about this young lady. By this time they had enough money to make a small hut under the Teak tree. One day, the prince could not resist his curiosity and followed the nurse into the forest. When he saw the lovely young girl, he decided to marry her.

However, the girl refused to go to the city to get married. And so , the king and his court had to come to the forest to solemnize the marriage in front of the Teak tree. The girl's father too came with his other daughters and everyone was grateful to the Teak tree for its wisdom and the care it bestowed on the two women.

Teak is botanically known as *Tectona grandis*. *Tectona* is derived from the vernacular name *'Tekka'* used in Malabar. In Portuguese also it is called *'Teca'*. The specific epithet *'grandis'* is used because of its large, handsome appearance. According to Hindu mythology, when the world was divided into *'dwipas'* or islands surrounded by the 'Sea of Milk', one of them was named 'Shaka' (the Sanskrit name for Teak) after the Teak tree that grew there (Gandhi and Singh 1989).

It is a large deciduous tree with quadrangular young branches and covered with hair and large, simple leaves in pairs. The flowers are small, borne in dense, white pyramidal clusters (Fig. 8.1), and the fruits are round or four-lobed, brown and spongy. The Teak is not a garden plant but is a source of valuable timber — as it is both insect- and white-ant-proof (Gandhi and Singh 1989). It is used for ship-building, railways, bridge-building, construction work as well as furniture and cabinet work. It is also used in making certain musical instruments such as violin keys, the long 'neck' of sitars, and the bodies of harmoniums. Different grades of plywood and boards are also made from it.

The largest and oldest Teak tree in Asia, probably 600 years old, or more, is at Parambikulam Game Sanctuary in Kerala, India.

Ebony

According to an Oriyan folk-tale, during the great deluge, a Kond, Kittung by name, and his wife took shelter inside a huge gourd. They took a bundle of sticks with them to make fire when they came out. When the water receded and the area was dry, they emerged from the gourd and using the sticks made a fire. Next morning, the two of them went to explore the new world. In their absence, one of the burnt twigs took root and grew into a tree — the Ebony tree.

There is yet another story: Manglo Saora, who had five sons and three daughters, lived on Mahendragiri. One day, when they were all cutting wood in the forest, the youngest daughter was bitten by a snake. The girl died and her body turned blue-black. The tree which arose from her grave was also black and this was the Ebony tree (Gandhi and Singh 1989).

Certain tribals, in India, use a pole made of Ebony tree to protect the fields of tobacco and chillies from sorcerers. The belief is that the sorcerer will be attracted by the pole and as the pole is black, the whole field will appear black, and therefore invisible to the sorcerer. The fields, thus, will be protected from any harm (Gupta 1971).

The tale of Hanuman from the *Ramayana* speaks of another reason why the stem of the Ebony tree is black. When Hanuman went to survey the city of Lanka, before the war between Rama and Ravana, the Lankans, under the order of Ravana, tied a large piece of cloth soaked in oil to his tail and lighted it. Hanuman jumped from building to building, setting the whole city ablaze. In the process, his hands got blackened and when he wiped his hands on the trunk of the Ebony tree, that too turned black.

The Urdu name for Ebony is 'Aab-noos' and the Sanskrit name is 'Tinduka'. It figures in the Jataka stories, that is the stories about Buddha's former births.

True Ebony also called 'Macassar ebony', is *Diospyros ebenum* (Fig. 8.2). An evergreen, medium-sized tree, its fruits are edible and the wood used for cabinet-work, decorative panelling, veneers, umbrella handles, wooden combs, musical

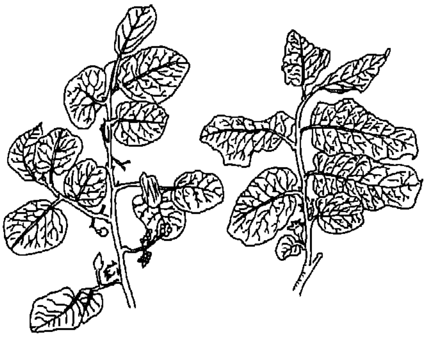


FIG. 8.2
Ebony tree, *Diospyros ebenum*, twigs.

instruments such as the keys of the violin, turnery, carving and sports goods (Singh et al.1990). *Diospyros* means 'Jove's Grain', referring to the edible fruit.

D. melanoxylon is the 'Coromandel ebony', distributed in Madhya Pradesh, Maharashtra, Orissa, Uttar Pradesh and Bihar. Its leaves are used for wrapping 'bidis', the popular 'smoke' of the common man in India. The leaves are collected each year, under contract, in government forests and sold. The wood is used for shafts, poles, brush-backs, walking-sticks, turnery, carving and billiard cues. The bark and half-ripe fruits are used for tanning. In addition, its fruits are edible. The species is considered important for afforestation (Singh et al.1990).

D. kaki is another important species. Commonly known as 'Japanese Persimon', this small-sized tree is a native of China and presently grown in Himachal Pradesh, Kumaon, the Nilgiris and West Bengal for its edible fruit. The wood is reported to be used for ornamental work in desks, boxes and mosaics.

The Andaman Marble wood or 'Zebra wood' is obtained from *Disopyros marmorata*, distributed in the Andamans and Western Ghats. Its wood is highly decorative as the heartwood is often streaked with black. It is used for cabinet-work, turnery, carving, brush-backs, picture-frames and walking-sticks (Singh et al. 1990).

Sandalwood

Since ancient days, the Sandalwood has been highly prized in India and China. In ancient literature it is mentioned that the paste obtained from '*Chandan*' (Sandalwood, *Santalum album*) was used in toiletery. In the *Ramayana*, it is mentioned that amongst other trees, Rama had seen the Sandalwood tree also. 'Malaya-Giri' of the *Ramayana*, i.e. the southern parts of the Western Ghats, south of the river Kaveri, abounded in the fragrant chandan.

Chandan was also used in the funeral pyre of King Dasharatha and, to this day, it is used for the same purpose by those who can afford it. The fragrant heart-wood is rich in oil. The paste made by rubbing a piece of sandalwood with a little water on a rough surface is fragrant and has a cooling effect. Often, this paste is applied to boils and other skin ailments. Both wood and oil have long been employed in Ayurveda. It is credited with cooling, diaphoretic, diurectic and expectorant properties. This is the first material evidence of Indo-Aryan borrowing from Dravidian culture in southern India during the Vedic period (ca.1,000-200 B.C.). It is acknowledged to be one of the precious perfumes from antiquity; its popularity has not shown any signs of waning.

The word 'sandal' has been derived from *Chandana* in Sanskrit, and 'Chandan' in Persian. Sandalwood has been referred to in Indian mythology, folklore and ancient scriptures. It is generally accepted that sandal is indigenous to peninsular India as its history of recorded occurrence dates back to at least 2,500 years.

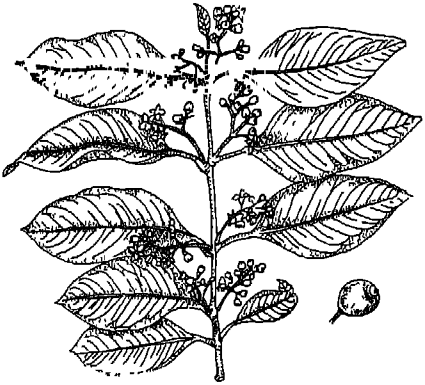


FIG. 8.3
Sandalwood tree, *Santalum album,* flowering twig and fruit.

The family Santalaceae (the Sandal family) is distributed between 30° N and 40° S from Indonesia in the West to Juan Fernàndez Island in the North, and to New Zealand in the South. In India *Santalum album* occurs almost all over the country — Karnataka, Tamil Nadu, Andhra Pradesh, Kerala, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Uttar

Pradesh, Bihar and Manipur. More than 90 per cent of the area is in Karnataka and Tamil Nadu covering about 8,300 sq. kms. The tree flourishes from sea-level up to 1,800 metres altitude in sandy, clayey red soils, lataritic loamy or even black cotton soils. Trees growing on stony or gravelly soils are known to have more highly-scented wood. The oil of East Indian sandalwood is one of the important essential oils produced in India on a factory scale (Bhatnagar 1965). It is a semi-parasitic tree, grows well in early stages under partial shade but is intolerant to heavy overhead shade at later stages. *Santalum album* (Fig. 8 3) is a small evergreen tree, a partial root-parasite which attains a height of 12 to 13 metres and a girth of 1 to 2 4 metres. As the tree grows, essential oil develops in the root and heartwood and reaches full maturity at an age of 60 to 80 years or more.

Because of the utility of the plant, its over-exploitation may lead to its extinction. The Government of Karnataka has, therefore, taken strict measures for its protection. Whether this tree is growing in any temple, private or public garden, park or lawn, it is the property of the Government of Karnataka, and nobody can fell a tree without prior permission from the Government. Every piece of wood purchased for carving has a stamp certifying that it has been purchased from the Government.

The wood is abundant, and yet expensive and this leads to smuggling and stealing of the wood in spite of strict watch by the Forest Department. Strong-smelling sandalwood pieces are often smuggled by packing them in onion or coriander bags.

Sandalwood has many uses. Throughout the East, it is much valued for domestic purposes. The paste of the wood is used for anointing the body after bathing. In West Bengal, the faces of the bride and the bridegroom are decorated with sandalwood paste.

The wood is an ideal material for carving idols, figurines, and various objects of art. Boxes, cabinets, walking sticks, small work-tables are also made from this wood. The carving of sandalwood is a highly skilled art and often the art remains within a family and is passed on from father to son. Sorabar, a town in District Shimoga in Mysore, has many such families.

It is said that in 1920, the police raided a place suspected of counterfeiting currency notes. To their great surprise the police came across a number of blocks made by carving sandalwood pieces, instead of any counterfeiting machinery. Every dot, grain and line, that are printed on a currency note were perfectly chiselled out on each block. The late Sir Visveswaraiah, the then Diwan of Mysore State, made all possible efforts to search for this man but unfortunately the aritist committed suicide.

Hindus, Muslims, Buddhists and Parsis use sandalwood powder as incense in their religious ceremonies. The Chinese use the wood for making 'Joss-sticks', which are burnt in temples. In Malaya, the natives mix sandalwood oil with other substances to perfume their steam baths. The oil is also used for ceremonial fumigation before prayers and the purification ritual of a corpse. In Burma the oil is used for the production of cosmetics. In some Polynesian Islands the oil is mixed with coconut oil to make it more pleasing. According to Tamil classics, sandalwood was mixed with 'aguru' wood (*Aquilaria agallocha*) and burnt, and over the perfumed smoke young maidens used to dry their hair.

The oil consists of alcohols and their corresponding aldehydes. The principal constituents are α– and β–Santalol $C_{15}H_{24}O$, Santene C_9H_{14} and α– and β–Santalenes $C_{15}H_{24}$ (Hydrocarbons), Santenol $C_9H_{16}O$ and Teresantalol $C_{10}H_{16}O$ (alcohols), Santenone $C_9H_{14}O$ and Santalone $C_{11}H_{16}O$ (Ketones) and a- and b-Santalic acid $C_{15}H_{22}O_2$.

The spent wood — after the extraction of oil — is used in the manufacture of 'agarbattis'. The oil is mainly used in the manufacture of oriental perfumes, soaps, toilet powders, creams and hand lotions.

With the appearance of sulpha drugs and antibiotics, the medicinal use of sandalwood oil has declined considerably.

With increased demand for sandalwood and its oil, and limited supply, aromatic timbers from various other plants from different parts of the world have been used as substitutes. Amongst these the important timbers are *Fusanus spicatus* (Australian sandalwood), *Esenbeckia alata* (West Indian sandalwood), *Amyris balsamifera* (Venezuelan sandalwood), *Ximenia americana* (West African sandalwood) and *Osyris tenuifolia* (East African sandalwood) (Bhatnagar 1965).

Margosa Tree

The *neem* tree (*Azadirachta indica*) has been well-known in India and neighbouring countries for more than 2,000 years, for its medicinal value and as an insect-repellent (Fig. 8.4) The Sanskrit name of *neem* is '*Arishtha*' — the 'reliever of sickness'. For centuries its fruits, leaves, oil, bark and roots have been used in Ayurvedic and Unani medicines. Dry neem leaves are used for protecting stored rice and wheat. The twigs of neem are used as a toothbrush in India.

Only in 1928 was the insect-repellent from *neem* reported. In 1959 Dr Heinrich Schmutterer, a young German scientist, worked in Sudan during a locust invasion. He observed that *neem* trees were the only plants that were spared by the locusts. These plants remained green and healthy—the swarms of locusts visited these plants but left them untouched. Investigations were taken up to study the properties of the chemical compounds in *neem* and their mode of action.

Recently, the importance of *neem* has been recognized by the U.S. National Academy of Sciences, and in 1992 a report entitled '*Neem* — A Tree for Solving Global Problems' was published. The following statement is recorded regarding this plant.

> *Neem* is a fascinating tree. On (the) one hand it seems to be one of the most promising of all plants and may eventually benefit every person on the planet... This plant may usher in a new era in pest control, provide millions with inexpensive medicines, cut down the rate of human population growth, and perhaps even reduce erosion (Schmutterer 1995).

Neem is named '*Azad-darakht-i-hindi*' (Persian) meaning 'free tree of India.' The Latinized name *Azadirachta* is derived from the Persian name. The name used in Tanzania is 'Mwarobainin' (in Swahili) meaning the tree that provides medicine for forty diseases (Schmutterer 1995).

The exact region of origin of this plant is lost in antiquity. Myanmar (Burma) and/or parts of southern India, such as Karnataka (Troup 1921, Vartak and Ghate 1990) are considered to be its native home. Another opinion is that large parts of south eastern and southern Asia from Indonesia to Iran is the area of origin. The great variability in the shape of its leaves and other morphological features in Myanmar supports the

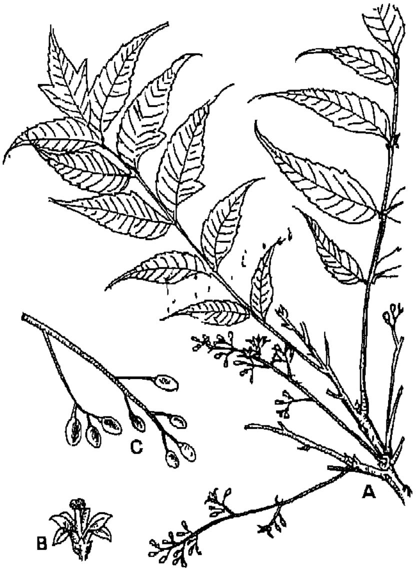


FIG. 8 4 A-C
Neem, *Azadirachta indica*. *A* Twig. *B* Flower, *C* Fruit.

former view (Oo 1987). *A. indica* is widely distributed by introduction in the arid tropical and subtropical zones of Asia, Africa, North and South America, Australia and South Pacific Islands. It can grow in poor soil but cannot withstand frost.

Indian farmers have used the seeds of *neem*, over a long period of time, as a natural insecticide for protection of crops and stored grains. Scientists have isolated compounds which are effective even in very minute quantities. The active ingredient 'azadirachtin' is extracted from the seed. The kernels are dried, decorticated, and *neem* oil is extracted from them. Bitter principles of *neem* oil are reported to have been obtained by extraction with alcohol.

Neem seed oil is effective, especially against sucking insects such as leaf-hoppers, aphids and white-flies, and also locusts. Pure azadirachtin is only slightly soluble in water but it almost completely dissolves in aqueous extracts of seed powder. After straining it can be used as insect repellent.

As a rule, *neem* does not form part of a forest and usually grows in the vicinity of human settlements. It has been used extensively throughout the length and breadth of India as a household remedy for treatment of common ailments, since time immemorial. The medicinal properties of *neem* were described in the early Sanskrit medical treatises. *Neem* is used in Ayurveda, Unani and Homoeopathic medicine. There are numerous curative properties attributed to *neem* in folklores and traditional medicines.

The *neem* bark exudes a gum the 'East-India Gum'. This amber-coloured gum acts as a stimulant, demulcent and tonic, and is used by silk-dyers in the preparation of coloured silks. 'Nimbin' and 'nimbidin' extracted from the stem- and root-bark are anti–protozoal, anti–allergic, anti–dermatitic and anti-fungal. The *neem* cake residue after extraction of the oil from the seeds is a good organic fertilizer The seed oil, Margosa oil, is a deep-yellow fatty oil, used in pharmaceutical preparations for face creams, hair lotions, toothpastes, disinfectants, and as an emulsifying agent for insecticides

The commercial potential of *neem*-based pesticides has attracted the industrialized countries. In 1993 the world's first commercial-scale facility, designed and built for *neem*-based natural biopesticide production opened in India. If the compounds in *neem* are patented by a foreign company, the Indian Industry would have to pay a royalty to be able to use this material for its own biotechnological units (Sahai 1993).

Rosewoods

There are two types of Rosewoods: the north-Indian Rosewood, *Dalbergia sissoo* or 'shisham,' and the Bombay Blackwood *D latifolia.*

Panini, the great Sanskrit grammarian, in his book *Ashtadhyayi* (500 B.C.), which comprises about four thousand hymns (or *sutras*), classified plants on the basis of leaves, flowers and fruits. The name '*Shingshupa*' for *Dalbergia sissoo* is mentioned in Panini's work.

The generic name *Dalbergia* commenorates N. Dalberg, a Swedish botanist of the late eighteenth and early nineteenth century. It is a large deciduous tree with a comparatively light crown and a somewhat crooked bole. Trees under favourable conditions can grow upto 30 metres in height, and 2 4 to 2.7 metres in girth. But under unfavourable conditions, the plants can be stunted with a crooked bole. It is abundant in the riverian alluvial soils of the sub-Himalayan tracts. Sissoo forms either pure forests or a mixed forest with *Acacia nilotica.* This is a classical example of a first colonist in the riverian succession of the Gangetic alluvium. When the course of the rivers or streams alter or fresh deposits are added to the soil, these are the

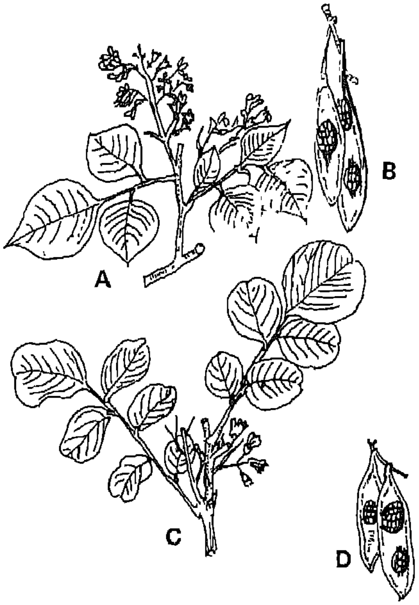


FIG. 8.5 A-D
A Dalbergia sissoo, twig with leaves and inflorescences. *B* Fruits
C Dalbergia latifolia, twig with leaves and inflorescences. *D* Fruits.

first tree species to appear on new sites. As the streams and rivers cut deeper in the valley, these forests are gradually elevated. As a result, after some years, successive terraces of these trees of different age-groups can be observed at various heights above the river-level.

It is distributed throughout the sub-Himalayan tract from the river Indus in the west to Assam in the east, and usually up to 900 metres altitude. Both irrigated (in Punjab, Haryana and Rajasthan) and unirrigated (in Uttar Pradesh) plantations have been raised since Independence. *Dalbergia sissoo* is being used for afforestation all over the country except in extreme cold, wet or dry regions. Although it is moisture-loving and grows well in the riverian tracts, it cannot tolerate bad soil drainage. It is widely planted as a road-side tree. Sissoo has a thick and longitudinally furrowed bark. The leaves are pinnately-compound; leaflets more or less rounded with a pointed tip (Fig. 8.5 A). With the onset of winter, leaf-fall begins and leaf-shedding is very regular over the whole forest. As a result, all the leafless trees of the riverian tract with a characteristic bare, grey appearance, contrast strongly with the sal forests (*Shorea robusta*) with their dark-green foliage, which usually occupy the higher grounds.

During spring, a profusion of cream-coloured fragrant flowers are produced along with new foliage. The young pods form very rapidly. These are thin, strap-shaped pods, pale-green and hanging in masses. The seeds are flat.

The timber of Sissoo is very durable and takes good polish. It ranks amongst the finest of India's cabinet and furniture woods. It is also used for bent-wood articles, skies, calico-printing blocks, musical instruments (keys of sitars), picture frames, tube of the hookah (hubble bubble), boat-building, tool-handles, and handles of agricultural implements. The wood of shisham is reported to be most suitable for making charcoal. The wood-pulp is used for making paper (Singh et al. 1990).

Dalbergia latifolia (Indian Rosewood) is also known as the Bombay Blackwood (Fig. 8.5 B). It is superior to *D. sissoo* and is common in the southern parts of India. It attains great heights in the dense forests of the Western Ghats. The heartwood (in this species) varies in colour from dull-brown to almost purple, and the sapwood is yellowish (Kochhar 1981). Also, it has a characteristic odour. It is a durable timber and particularly so under water. Indian Rosewood is not an easy timber to work with but it is good for wood-carving. The wood is also used for furniture, cabinet work, ornamental ply-boards, bent-wood articles, calico-printing blocks, musical instruments (keys of violin), hair-brush backs, picture frames, and others (Singh et al., 1990).

About this timber, Watt (1890) states, "The timber is one of the most valuable in India, is strong, very hard, close-grained and of purple-black hue. It takes a beautiful polish, is reckoned the best furniture wood" (Santapau 1966).

Given below are other species of *Dalbergia* which also provide useful timber.

D.melanozylon, African Blackwood or 'Sudan ebony', is a small tree distributed in Tamil Nadu, Karnataka, Maharashtra and Bengal. The wood is used for musical instruments, handles of surgical instruments, walking sticks and fancy articles.

D nigra, Brazilian Rosewood, is a native of tropical South America. It yields a rose-scented heartwood which is brown or violet with irregular black streaks. The wood is used for cabinet work, brush-backs, knife-handles and other such articles.

D. stevensonii, or 'Hondurus Rosewood', is an ornamental cabinet timber. It is used for making musical instruments such as the bars of xylophones (Kochhar 1981).

D. assamica is a tree distributed from Kumaon Hills to Assam. It is often grown as a shade tree in tea plantations.

D lanceolana, commonly called 'Bithua', is a tall deciduous tree scattered all over India. Its wood is used for agricultural implements and tool-handles.

9

Rubber

Even before the discovery of America by Columbus, the use of rubber was well-established amongst the ancient civilizations of the Incas of Peru, the Aztecs of Mexico, and the Mayas of Central and South America. The use of rubber by the local inhabitants of Mexico was discovered by the Spanish explorers in 1521. Gonzales Hernandez de Oviedo Y. Valdes — in his book, *Historia General,* published in 1535 — mentions the famous ball-game. Tenochtitlan was the capital of the Aztec rulers. In the heart of the city was the walled precinct where the principal temples, priests' quarters, and important material were kept. Also, in the precincts were long I-shaped courts used for the sacred ball-game. Players propelled a rubber ball back and forth over a line across the centre of the court, and were supposed to use only their hips, knees and elbows. At the mid-point of each side-wall, high above the ground, was a projecting stone ring with a hole just big enough to allow the ball to pass through. If any player managed to pass the ball through a ring, his team won outright. The ball-game was a favourite sport and was an ancient custom in the whole of Middle America.

The Aztecs also used this game for a kind of foretelling. When in 1519, Hernando Cortez from Spain, landed on the coast of Mexico, the Aztec ruler was the all-powerful Montezuma. It is said that sometime before this attack, there was a prophecy about it. To test the truth of the prophecy, Montezuma played against the ruler of Texcoco (another nearby city). The legend records that Montezuma won the first few games but was finally defeated. It was soon after this defeat that Cortez landed and conquered Mexico. The material from which the ball for the ball-game was made, was the sap (latex) of a tree. The Mexicans could also make water-tight shoes and protective garments from this latex.

During his second voyage to the New World, Columbus saw the children of Haiti playing with light, hollow balls which bounced as if they were alive. Later, the Portuguese explorers noticed that the inhabitants of the Amazon river valley, water-proofed their hats, clothes and shoes with rubber latex. Some explorers also noticed the Mexican Indians chewing the hardened latex of guayule (*Parthenium argentatum*) shrub. Samples were taken to different European countries but not much interest was shown because knowledge about these plants was scanty and very few latex-yielding plants were known to them.

About 1730 the French Academy of Science became interested in the subject and sent explorers into the Amazon river valley. In 1736 one of the members of this group — M. de La Condamine, a physician and naturalist — brought back a sample of 'Caoutchouc' (from its Caribbean name *'Cahuchu'*) and studied its properties. The sample was obtained from a local tree called 'heve', which was later used to form the generic name of the rubber tree — *Hevea*. In 1755 several pairs of boots belonging to the King of Portugal and 2,000 soldiers' haversacks were sent to Para (the chief port of the Amazon from where rubber was shipped) to be coated with latex to make them water-proof. It is reported that the natives of Penang, Malaya, carried their food and water in vessels and bags made from the hardened latex of the native tree *Ficus elastica*, during the late eighteenth century. In 1763 two French chemists discovered that the latex could be dissolved in turpentine and used for making surgical instruments and laboratory tubings. The French surgeon, Macquer (1768) pointed out that ether was a better solvent than turpentine and tried catheters (tubular instruments to draw off urine) made of the latex.

The year 1770 is a memorable one as the English chemist Joseph Pristley accidentally noticed that pencil marks could be erased with it and little cubes of India rubber, half-an-inch thick, were put on the market in London at three shillings a piece by 1780. At the same time, rubber balls were made in France and sold as toys. The prefix 'India' came from the belief that the plant was discovered in India.

This was the scenario in the European countries. But in the United States of America the situation was different. Here the rubber used to become sticky during summer and hard like rock during winter. Charles Goodyear (1800-60) felt that God had sent him to this world to fulfil the mission of getting the right kind of rubber. For his obsession with rubber, he was even considered a harmless lunatic. At one time, when he was living in New York, a saying about him became popular : "If you meet a man who wears India rubber cap, stock, vest and shoes, has a money purse made of India rubber, without a cent of money in it — that is Charles Goodyear !" This obsessed person discovered the process of vulcanization in 1839. Although a hardware merchant, he had an inventive turn of mind. His laboratory was his wife's kitchen; his equipment consisted of pots and pans, a rolling pin, knife and raw rubber and some chemicals. Having no other source of income, he often had to sell or pawn the household items for his experiments. All the while debtors were after him and several times he was put behind bars. It was during the worst part of his life in 1839, when his family was on the verge of starvation, that he made the discovery that made him world-famous. One day, by accident, he spilled some of his mixture of rubber and sulphur on a hot stove. He was amazed to see that the piece had become harder instead of melting as he had expected. He kept this piece of 'rubber' outside the door in the open to see the effect of night-chill on it. It remained unaffected.

This discovery of Goodyear revolutionized the entire rubber industry of the world. He called this process 'vulcanization' after 'Vulcan', the Greek God of Fire and patented this discovery in 1844.

Within 15 years, an intense exploitation of rubber was started and it is said that the entire population of Para set itself to harvest rubber. Everyone including the mechanic, the factory owner as well the farmers stopped their work and got themselves engaged in tapping the trees for latex. After collecting the latex, the natives would dip a broad paddle into it and turn it about in the smoke of a fire to harden it. The process continued several times, till a ball weighing about 10 kg was obtained. After removing it from the paddle, it was set aside for export.

Following the invention of vulcanization by Goodyear, a large number of factories sprang up in various countries, manufacturing rubber products. Solid rubber tyres were first used on road vehicles in 1867. A British veterinary surgeon, John Boyd Dunlop (1888), developed the pneumatic bicycle tyre, and the motor car tyre was developed later.

To start with, the entire supply of rubber came from the wild trees of the Amazon river valley. But after the invention of vulcanization, the demand for rubber increased. A far-sighted Englishman named Collins (1860) cautioned his government about the difficulties of obtaining raw rubber from Brazil. Another Englishman, Sir Clements Markham, is credited with the decision to domesticate one of the latex-yielding plants in the Far East. He engaged James Collins to survey the latex-yielding plants of the world so that the most suitable one could be planted in the East. Brazilian Hevea, i.e. *Hevea braziliensis* (Fig. 9.1) was the first choice. Farris, in 1873, collected some seeds of *Hevea* which were sent to the Botanical Garden at Kew, London. The plants raised from these seeds were finally sent to the Royal Botanical Garden at Calcutta, India. But, unfortunately, they did not survive. Afterwards, Robert Cross was sent to Brazil and when he returned, he brought, 1,000 seedlings of *Hevea* with him. But they too did not reach the Far East.

About 1876, Sir Joseph Dalton Hooker commissioned Sir Henry Wickham, a planter, then living in Brazil, for procuring the seeds of *Hevea*. The seeds are rich in oil and soon lose their viability. Hence, it was essential to ship them at the earliest opportunity and sow them promptly. Facing all the difficulties in the tropical moist forests of the Amazon valley, Wickham was successful in his mission. He successfully

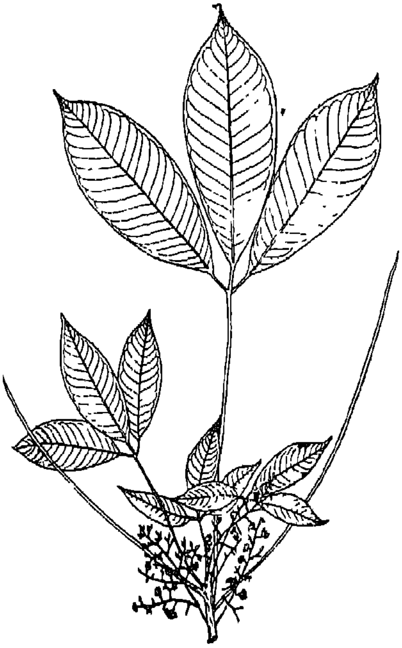


FIG 9 1

Rubber tree, *Hevea braziliensis*, comes all the way from the Amazon river valley in Brazil.

smuggled out the seeds from Brazil in a specially chartered ship with the consignment labelled "exceedingly delicate and valuable specimens for Queen Victoria's Garden at Kew." A special night train awaited him at Liverpool and Wickham reached London with 70,000 seeds. Without delay, he rushed to Sir Joseph Dalton Hooker, the then Director of the Royal Botanical Gardens. Next morning, all the seeds were planted at Kew, in every possible place. From this lot about, 3,000 seeds germinated. Two months later about 1,900 young plants were despatched in 38 miniature greenhouses called Wardian cases. Two were sent to the Cultuurtium at Buitenzorg (West Java); twenty-two were sent to the Singapore Royal Botanical Garden, and the rest to the Royal Botanical Garden at Penang (Malaya). A gardener accompanied these seedlings during their voyages to look after them. Probably no deck cargo was ever looked after with such loving care as this batch of young plants of *Hevea.* About 90 per cent of the seedlings landed in good condition. It was from these seedlings, the twenty-two sent to Singapore in particular, that the vast rubber plantations and rubber industry of the South East Asian region developed. Of course, like any new thing, rubber was also not accepted very easily in the Far East. Most planters were growing coffee as a major economic support in these regions and would not easily give it up. The Director of the Royal Botanical Garden, at Singapore, Sir Henry Ridley (1889), tried to persuade the planters to give the new crop a trial: But he was ridiculed and called 'Mad Ridley'. He was even officially reprimanded by his superiors for his futile efforts.

Somehow, luck favoured him. On the one hand, coffee prices slumped and many plants were attacked by pests and diseases. On the other hand, the demand for rubber kept increasing and prices soared high. Ridley did not let go this opportunity. He told the farmers that the rubber plants had arrived at just the right time as their saviour. As a result of Ridley's sustained efforts, today approximately half the rubber of the world comes from Malaya where three million acres of land are under rubber cultivation. This is no doubt largely due to the selection of high-yielding clones of rubber trees, improvement in tapping technique, and in the processing of raw material. But, yet, there is another reason. In the New World, whenever rubber plants have been grown as plantation crop, they have been infected by the fungus *Microcyclus ulei* (syn. *Dothidella ulei*) causing the leaf-blight disease. However, it is not a serious pest in South East Asia.

Hevea braziliensis is a native of Brazil but it has found a more favourable home in the East. From time to time, trials have been made to establish rubber plantations in the West by the United States of America but to no avail. Firestone Rubber Company selected Liberia for starting rubber plantations in 1925; Ford Motor Company started the plantations in Brazil in 1928; Goodyear Tyre and Rubber company selected first Panama and later Costa Rica (in 1935) for the cultivation of rubber. Although the start was promising, infection by *Microcyclus ulei* at a later stage was disastrous.

During World War II, the Japanese invaded South East Asia — one of the reasons being the desire to close the rubber producing areas to the Western powers. The loss of Malaya and Indonesia was a blow to them. Thus, they were now looking for alternate sources for natural rubber. Although plants like *Taraxacum kok-saghys* (Russian dandelion), *Parthenium argentatum* (Mexican guayule) and *Cryptostegia grandiflora* came to be known as alternate sources, they were in no way comparable to *Hevea braziliensis*. The synthetic rubber industry also got a boost during this time, and in the early 1960s it equalled natural rubber in world output and moved ahead afterwards. In spite

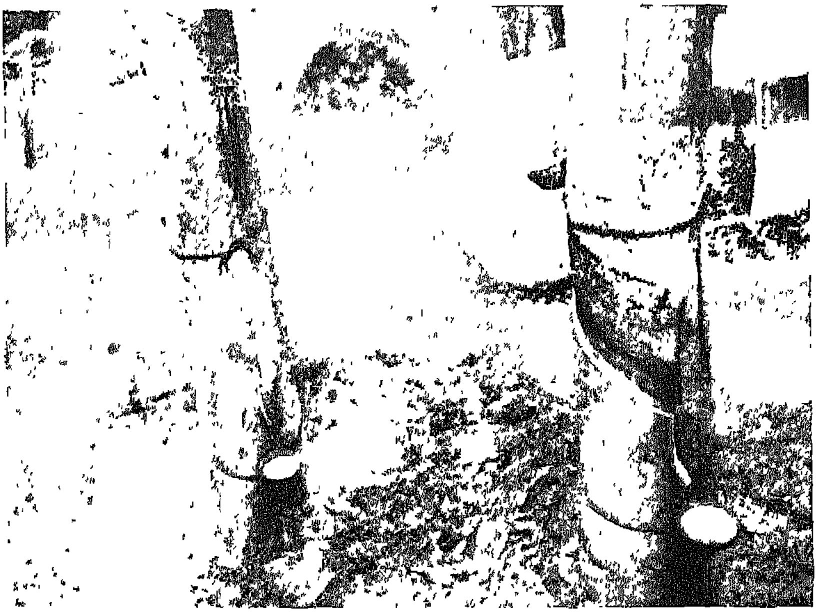


FIG 9.2

Hevea braziliensis, collection of latex.

of this competition, natural rubber continues to hold an important place in industry.

The milky sap or latex (Fig. 9.2) occurs in special cells or vessels — the laticifers. Usually the latex from the lower part of the stem is commercially important. The milky white fresh latex contains varying proportions of various non-rubber constituents such as proteins, resins, sugars, glycosides, tannins, alkaloids, mineral salts, waxes and crystals, and the rubber hydrocarbon (C_5H_8). Each rubber particle is spherical to pear-shaped with three distinct regions : an inner semi-fluid region of pure rubber hydrocarbon, the middle viscous rubber skin, and an outer protective protein covering that prevents coagulation of the particles. Non-rubber constituents may be adsorbed on the surface of rubber particles or may float in the serum (Kochhar 1981).

The concentrated latex is usually rolled and smoked to make 'sheet' rubber, or the finished product may be 'worm' rubber consisting of worm-like scrapings from sheet rubber, or 'crepe' rubber made by passing coagulated latex through creping machine which forms thin perforated strips, or 'sprayed' rubber made by dropping latex on whirling discs (Johri and Srivastava 1978). Most of the rubber is exported in the form of 'sheet' rubber.

Rubber is indispensable in the modern society. It is usually said: "We ride on rubber, we walk on rubber, and even rest and sleep on rubber." Nearly 50,000 different products are made directly or indirectly from rubber. The automobile industry, the footwear industry, wire and cable insulations, rubberized fabrics and a host of others are dependent on rubber.

10

Wealth from Grasses

THE most important commodities required by man are food and drink. The chief kind of food, which for thousands of years has occupied the principal position in the diet of most of the civilized world, are cereals.

Cereals

The word 'cereal' is derived from '*cerealia munera*' the gifts of Ceres — the Roman Goddess of Agriculture. The Romans used to offer grains of wheat and barley to their God. As a matter of fact, a grain of one kind or the other forms the basis of the diet of mankind, There are, however, a few exceptions. The inhabitants of the frozen north live principally on fish; certain primitive tribes of the tropical forest feed on fruit and roots, and some of the tribes from the hot deserts live mainly on dates. It may be observed that all the people named above are much behind in the march of civilization, so much so, that they still obtain at least a part of their food by the most antique method — simply gathering from nature. They have not practised agriculture, because the respective climatic conditions in which they live, render it impossible for them to do so. Another important point is that all the ancient civilizations have come up in those areas, where one or the other of the cereals have been grown from antiquity. According to Mangelsdorf (1953): "No civilization worthy of the name has ever been founded on any agricultural basis other than the cereals". The ancient civilizations of Mesopotamia (present-day Iraq) — Babylonian, Sumerian and Assyrian — depended on wheat and barley. These grains were also responsible for the Egyptian, Greek and Roman cultures. For the ancient people of India and South East Asia, rice was the most important grain. The pre-Columbian civilizations of the Mayans, Aztecs and Incas were based on maize.

The ancient man used to collect grass 'seeds', i.e. the one-seeded fruits, for food. The grains from wild grasses are still harvested in the drier parts of Africa. The native Red Indians harvested the grasses in a different way in the Great Lakes region of North America. They collected the grains of the aquatic plant of Wild Rice — *Zizania aquatica.* The canoes were paddled among the plants and the grains were beaten off the plants into the canoes. The wild grasses whose grains were collected had a peculiar feature that their inflorescences shattered when the grains ripened. In this way the dispersal of individual seeds was possible — an important feature of wild plants.

With improvement by breeding and selection over a long period, the modern cereal crop has been developed. In this crop the stem is tough and does not break when the grain is ripe. The grains remain in the inflorescence, protected by the sterile bracts, and are harvested all-together. The chaff or the covering of fertile and sterile bracts can be easily separated in barley and wheat; without much difficulty in oats; the whole grain-bearing cob is well-protected within the leaves in maize. Amongst all these different cereals, maize is the most advanced as it has lost its original power of seed dispersal. This character, however, was a boon in pre-agricultural days. Accidentally, some of these grains might have got scattered and gave rise to the plants near the abode of these people. The luxuriant growth of the plants (it is assumed that the ground was rich in organic matter and nitrogen as it was near the habitation), and the grains ready-at-hand might have inspired the food-gatherer to turn into a food-producer. He now deliberately scattered the seeds to get the grains at the time he wished. Thus, agriculture took root, in all probability, independently in different parts of the world, about 9,000 B.C.

Amongst the food crops from grasses, the six important cereals of the world are wheat, rice, maize, barley, oats and rye. Oats and rye are frequently used in the coldest regions near the North Pole. Wheat and barley are the important cereals of the warm temperate regions, and in the tropical zones rice and maize are dominant.

Wheat

Wheat is the most important amongst all the cereals. Bread-wheat (*Triticum aestivum*) is a widely grown food crop of all continents except Antarctica. Because of its extraordinary geographical distribution, it may be assumed that there are wheat plants growing and maturing at all times of the year in some part or the other of the world. However, it can be grown only within certain climatic limits, i.e. from the equator to 60°N and 45°S with maximal concentration in the warm temperate regions. Here the cool winters are followed by relatively dry and warm summers. This climate is known as 'grassland' climate and receives a moderate annual rainfall of 30 to 90 cm.

The genus *Triticum* includes several cultivated as well as wild species. The Russian scientist N.I. Vavilov recognized 14 species; others have proposed fewer or more. All the scientists, however, agree that all these species can be placed in three distinct groups : diploid, tetraploid and hexaploid, with the base chromosome number $x = 7$. The cytological studies were undertaken by Sakamura (1918) in

Japan. On the basis of morphological, anatomical and chemical studies, a German botanist, August Schultz, recognized these three groups earlier in 1913.

The 14-chromosome diploid wheats are perhaps the most ancient. There are two species, *T. boeoticum* (Wild Einkorn) and *T. monococcum* (Einkorn). The name Einkorn is derived from the fact that each spikelet in the inflorescence has only one seed. Wild Einkorn is probably one ancestor of all the cultivated species of wheat. It is native to the Middle East and south-eastern Europe. There was the tendency in these plants, of the inflorescence breaking up into parts and aiding in dispersal. The harvesting method was also unusual. As depicted in Egyptian tablets, a cluster of plants was grasped together and cut higher up from the ground so that the inflorescence received least shaking. Cultivated

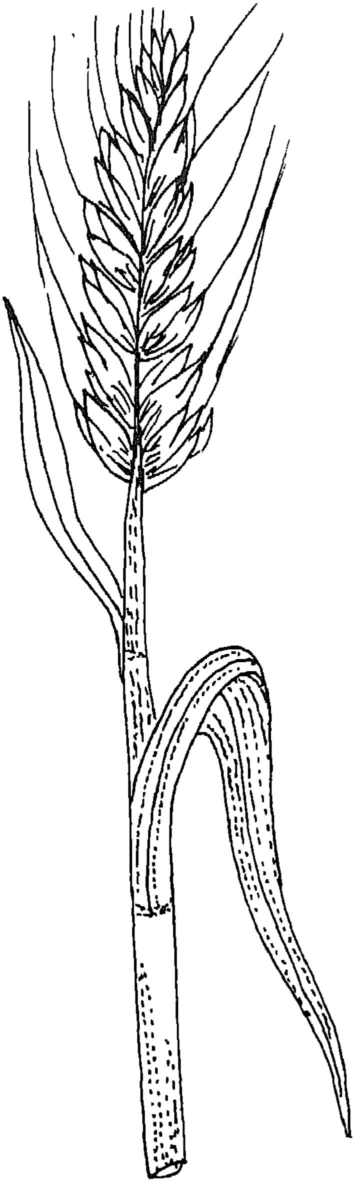


FIG. 10.1 →
Wheat, *Triticum aestivum*, inflorescence and mature grain.

Einkorn with slightly larger grains is a domesticated version of the wild species. It was grown in south-eastern Turkey and spread to Europe from Spain to Scandinavia by Neolithic times (ca. 8,000 B.C.). It is still grown in the hilly regions of some parts of Europe and the Middle East. Einkorn cannot be used as human food as the grains are firmly covered by the glumes and used commonly as cattle-feed. The carbonized remains of wild Einkorn and imprints of grains in baked clay have been discovered from the town of Jarmo (of the Neolithic period) in the Tigris-Euphrates basin in northern Iraq. Wild Einkorn has been reported from some other prehistoric sites such as Ali Kosh in south-eastern Iran (7,500-6,750 B.C.), Hacilar in West Central Anatolia (7,000 B.C.), and Tell Mureybit in northern Syria (8,000 B.C.).

The second group includes the 28-chromosome tetraploid wheats with seven species. The Wild Emmer wheat or *Triticum dicoceoides* grows naturally in the Middle East and is apparently derived from crossing Wild Einkorn (*T. boeoticum*) with a wild grass *Aegilops speltoides*. The constitution of hybrid is diploid but by accidental chromosome-doubling a tetraploid is produced. From the ancient town of Jarmo and some ancient caves in Europe and the mummies in Egypt (ca 2,500 B.C.) the seeds of wild and cultivated 'Emmer' wheat have also been discovered. All efforts to germinate the carbonized wheat grains from the mummies have failed. It was the chief cereal of the Mediterranean region until the Graeco-Roman period. Although good quality flour for bread-making can be obtained from Emmer wheat, the two qualities, fragile stem and clasping glumes, have turned it into cattle-feed.

Another tetraploid is the 'Durum' wheat (*T. durum*). Because of its high gluten content it is used in making macaroni, spaghetti, semolina and vermicelli. It is grown extensively in many European countries and in the United States of America.

The hexaploid or the 42-chromosome wheats, include five species. These have evolved recently. All the species are cultivated and are most useful to man. These modern wheats are the products of a natural cross between tetraploid wheats and a wild grass, *Aegilops squarrosa,* followed by doubling of chromosomes.

The most important hexaploid wheat is *T. aestivum* (Fig. 10.1) — the common bread wheat. Wheat spread all around the world soon after its domestication. Bread-wheat is known to have been grown in the Nile valley by 5,000 B.C., in the Euphrates-Tigris and Indus river valleys by 4,000 B.C., in China by 2,500 B.C., and in England by 2,000 B.C.

Columbus tried to introduce wheat to the New World (to Haiti) in 1493, but it did not survive. The successful introduction was by the Spaniards to Mexico in 1529. It was grown for the first time in Australia in 1602, in Virginia (USA) in 1611, in California in 1769 and in Minnesota in 1845 (Kochhar 1981).

The hexaploid wheats, at present, are grown all over the world, except in the Arctica and Antarctica. Their value lies in their productivity and yield, and because they can be threshed and winnowed easily, and the grain quality is rich in starch and proteins (particularly gluten) that helps in producing leavened bread.

Man played only the role of a selector in the evolution of wheat. Now that it is a well-established crop, geneticists have been taking good care of it since the beginning of the twentienth century. Many new varieties have been developed, including the rust-resistant varieties, dwarf varieties and hybrid wheats.

Rice

Rice is the staple food of more than 60 per cent of the world's population. In legend and religion around the world, rice is regarded as a precious gift of God. According to a Chinese folktale, in ancient days rice was not in the shape of small grains. Every family used to receive annually one large grain as a gift from God. Everyday, they could break a small portion, cook it and eat it. One day, however, an over-enthusiastic young man wanted to know how and when the huge big grain came to the village and who brought it. God became annoyed with the youth and punished his people saying, "Hereafter, you will have to toil in the field to obtain your daily food of grain". God did not send his precious gift any more, and the Chinese started growing it in the fields.

The main food crops cultivated in the Vedic period (1,000-800 B.C.) included varieties of paddy, 'Dhanya' as it is known in Sanskrit. Panini, the great Sanskrit grammarian, in his book *Ashtadhyayi* (500 B.C.) refers to the cultivation of regional plants. The fields were named by the crops which were grown in them, e.g. field of '*Vrihi*' meaning paddy, or rice fields. A number of varieties have also been recorded: (*a*) *Sali*—This is different from *Virihi* as stated by Kautilya; (*b*) *Mahavrihi* — a well-known variety in the time of Panini; (*c*) *Hayana* — a variety grown by transplantation; (*d*) *Shwastika* — ripening in six weeks; and (*e*) *Nivara* — a wild variety of rice.

'Dhan' or 'Dhanya' is also mentioned in the *Ramayana*. Carbonized rice dating back to about 1,000 B.C. has been discovered in the Hastinapur excavations dating back to 2,300 B C., and in the Lothal excavations in Gujarat. Lothal is supposedly a southward extension of the Harappa and Mohen-jo-daro culture of the Indus Valley Civilization (Kochhar 1981). The traditional use of rice in various religious functions of Hindus, be it birth, marriage or death, also supports its antiquity. The use of rice is mentioned in Chinese scriptures which are as old as 2,800 B.C. The remains of rice have also been reported from the Yung Shao excavations in China, dating back to 2,600 B.C. In China, the Emperor himself used to take part in a religious ceremony of sowing rice seeds. From many legendary stories of ancient China, it was presumed for a long time to be the place of origin of rice. Only one fact goes against this — wild relatives of rice are unknown in China.

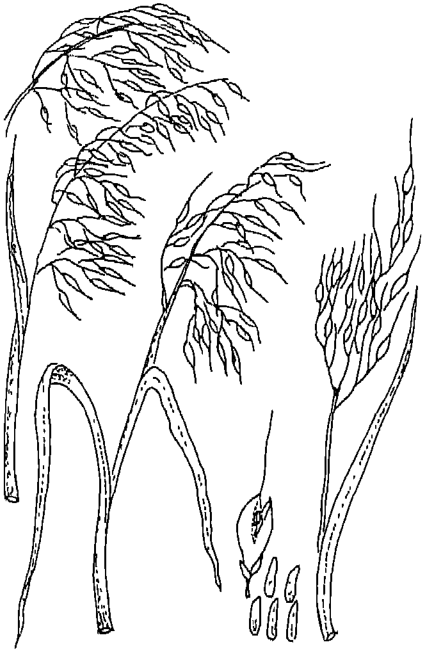


FIG. 10.2
Rice, *Oryza sativa*, inflorescences, flower and grains.

According to another viewpoint, rice was domesticated in India or Indo-China. The southern part of India is ideal for the cultivation of rice as there are large expanses of marshy lands, which also face frequent inundations. There are other supportive facts like numerous varieties of cultivated rice, presence of nearest wild relatives, and many dominant genes in Indian rice varieties. Rice spread eastwards to China, and then to Japan, and westwards to Iran, Iraq, Turkistan (Turkey) and Egypt. It was Alexander the Great who introduced this crop to Europe in 300 A.D. It was introduced to the American colonies in 1647. Commercial production came from South Carolina in 1685.

The wild perennial rice, *Oryza longistaminata*, is the probable ancestor of both the cultivated species, *O. sativa* (Fig. 10.2) and *O.*

glaberrima The former is extensively cultivated in all the warmer regions of the world, has about 8,000 varieties of which over 4,000 have been identified in India alone. The other species are grown in tropical Africa only.

More than 85 per cent of the world's rice production is from China, Japan, India, Bangladesh, Pakistan and the island countries of Southeast Asia. It can be cultivated from 50° North in Central Czechoslovakia to 35° South in Australia.

Majority of rice-growing areas are located at low elevation, but it is also grown at altitudes over 2,000 metres. Usually, the crop is cultivated in extremely wet conditions with more than 3000 mm rainfall during its growth period. At the same time, it is also grown in xeric climate of desert areas with less than 50 mm rainfall during the growth period. This is also true for temperature fluctuations. Rice can be grown in areas with mean monthly temperature of 33°C to 17°C. Hence, it is difficult to give an exact definition for rice climate.

In the coming years the population will continue to increase, particularly in the developing countries. Therefore, the need of the hour is to increase and stabilize rice production in irrigated areas, and to increase production under unfavourable environmental conditions. In addition, one has to remain alert since new problems of plant health and soil-care come up all the time. Therefore, there should not be any relaxation. Instead, dynamic research programmes should continue to sustain the dynamic production programme (Swaminathan 1984).

Corn

Corn, Indian corn or maize (Fig. 10.3), is the third major cereal. It originated in America and has become an important crop in the grasslands of the south and south-west of the Great Lakes, known as

FIG. 10.3

Maize, *Zea mays*, the cobs.

the corn belt. The earliest (oldest) remains of maize are from Mexico. It is said that at the time of Aztec rulers, the imperial city of Tenochtitlan used to receive annually more than 9,000 tons of food in the form of maize, beans and edible seeds. Aztec philosophy was full of symbolism which was often represented in the various ceremonies and festivals. In one such festival, during the feast in honour of the 'Maize Goddess', young women were beheaded as they danced, to symbolize the harvesting of the maize cobs. During the Inca Civilization in the mountains of the Andes (Peru, South America), the Royal Palace at Cuzco had a garden of gold, with life-sized stalks of maize and corn cobs, animals and birds. The economy of the Inca Empire was based on farming and maize was their staple grain. The diet of the common man was monotonous, consisting largely of soups and stews, with maize, beans, squashes, and potatoes as staple foods. The name 'maize', too, is derived from the South American Indian Arawak name 'mahiz'.

Although it is presumed that maize originated in Guatemala and southern Mexico where it was cultivated long before Columbus' discovery of the New World, there are some controversial viewpoints also. The oldest known cobs are usually small when compared with those grown now and are the popcorn type. Edger Anderson, an American ethonobotanist, observed that such small-eared variety (also of popcorn type) are grown in the Naga Hills of Assam in India by the tribals. He suggested, therefore, that this was the place of origin of maize. If we consider this concept to be true, then maize from the Old World was transported to the New World, many thousands of years ago. However, there is no evidence — archaeological, linguistic or historical — to support this view. Even in the ancient literature of the Chinese (ca. 2,600 B.C.) or the Vedas of the Hindus (1000-800 B.C.), there is no mention of this plant. Most authorities, therefore, do not accept the pre-Columbian existence of maize in the Old World. On the contrary, their introduction must have started soon after the discovery of the New World. E.D. Merrill (mentioned in Baker 1970) is of the opinion that the same voyages that carried peanuts, might have carried the maize grains also along with the peanuts. The Portuguese trade route from Lisbon to Asia by way of Brazil and then around the Cape of Good Hope, was used for 165 years after it was started in A.D. 1500. It is interesting that popcorn, including a form like the one which grows in the Naga Hills in India, is also reported from eastern Brazil. There could be another route — the one followed by the Spanish carriages from Mexico to the Philippines, and then to China. The third possible route is somewhat complex — from the New World to Spain across the Atlantic Ocean, then to the eastern Mediterranean, and from there overland to China.

Mangelsdorf (mentioned in Baker 1970) suggested Andean origin of maize as popcorn is of frequent occurrence in some of the prehistoric remains of Peru. The presence of pottery utensils used for popping corn has also been reported from these areas.

The first direct archaeological evidence for the popcorn-podcorn origin of present-day maize was discovered only in the 1950s, in an abandoned Indian rock cavern in New Mexico known as 'Bat Cave'. In successive levels of the floor of this cave, human skeletons, artifacts and other things dating from 3,500 B.C. to A.D. 1,000 have been discovered. At the bottom of the pile were maize ears which were very small with irregular rows of grains. However, this only reflects the oldest specimens of maize. The wild ancestor still remained a mystery.

Recently, more excavations were carried out in the floors of some caves in the valley of Tehuacán, about 150 miles south of Mexico city. The first evidence of truly wild maize (of 5,000 B.C.) was recovered from Tehuacân. The tiny ears of these plants were less than an inch long, with only a couple of husk leaves. The brownish round grains, with relatively long glumes, are borne on fragile 'cobs' so that seed-dispersal is easier. The staminate inflorescence grew from the tip of the cob. There was no other cultivated plant along with the maize plants, fanning the idea that it was collected in the wild form. But, it is also true, that within another 500 years selection of races was in progress and the wild maize was wiped out between A.D. 200 and 700.

The origin of maize remains only an assumption, and there are many hypotheses about it because a living specimen of the wild form of maize has never been discovered.

The different hypotheses are

1. The origin of maize might be from its nearest wild relative; *Teosinte.* It is a Central American plant and the Aztecs named it *Teocnte;* botanically it is *Euchlaena mexicana.* The two genera *Euchlaena* and *Zea* have ten pairs of chromosomes each, and artificial hybrids between the two are highly fertile. Both have separate male and female flowers borne in tassels and ears, respectively, but in *Teosinte* there are only five or six grains, each enclosed in hard glumes. This theory is not tangible because

    (a) A series of cytogenetical studies proved that *Teosinte* cannot be an ancestor, instead, it can be a descendant from a natural hybridization between *Zea mays* and *Tripsacum* (another grass).

    (b) The discovery of fossil pollen of maize, nearly 80,000 years old, about 60 metres under Mexico city, whereas *Teosinte* was never recovered below 3-4 metres.

(c) *Teosinte* grows wild in Guatemala and Mexico, among the maize plants. These maize plants show much diversity. But, probably, the same type of variation is common amongst the maize plants growing on the eastern slopes of the Andes in Peru and Bolivia.

2. A more plausible explanation is that maize originated from a wild pod-corn in which each grain had scanty husk around it.
3. The cultivated maize of today cannot survive without man's help and care. The grains of the cob are enveloped by a tough, thick husk preventing it from scattering. The entire cob — with all its seeds firmly attached to the central zone — could germinate under suitable conditions only. But that would lead to a competition amongst the seedlings, and all the seedlings might disintegrate.

Inbreeding sometimes results in the formation of unusual species. In one such resultant, the lateral ears disappeared and the kernels were borne at the bases of the tassel branches and enclosed in glumes. By making crosses between pop- and pod-corns and back-crossing the hybrid to the pop-corn repeatedly, Mangelsdorf succeeded in obtaining a fertile hybrid with many presumably primitive/ negative characters.

The two primitive forms of maize from the foothills of the Himalayas, 'Sikkim Primitive 1' and 'Sikkim Primitive 2', are strikingly similar to this hypothetical ancestor synthesized by Mangelsdorf.

Hybrid Corn

Although the origin of maize is shrouded in mystery, its recent history is well-documented and rather interesting. The development of hybrid corn has revolutionized agriculture in the American corn belt.

Continuous inbreeding leads to 'inbreeding depression' and the plants rest at a very low level of vigour after a few generations. If plants from two such lines are hybridized, the resultant species shows a high degree of hybrid vigour. During the first step of this experimentation, only 'single-cross' method was adopted. In this method the inbred strains that were used as seed-parents produced small ears with a small number of grains, and therefore this did not appeal much to the farmers. Moreover, this method is time-consuming and too expensive.

In 1918, Donald Jones of Connecticut Agricultural Experiment Station, introduced the 'Double-cross' method in which four inbred strains are combined. Before the ultimate seed for commercial production is obtained, two hybridizations in two seasons are necessary. The seed can be sown in the third year to obtain vast quantities of cobs and grains, although genetically these grains were less uniform. However, with further research, hybrid maize now has characters like disease resistance and climatic adaptation in addition to high-yield.

In 1965, scientists at the Purdue University (West Lafayette, Indiana, USA) discovered a new variety of corn and named it 'Opaque 2'. Its kernels were impermeable to light. This new variety was rich in lysine and tryptophan, the two amino acids needed by the human body for normal and healthy growth. Initially it was very promising as there were visual changes in health conditions when tested on rats, pigs and also malnourished children. However, it was soon realized that the softer kernels were not suitable for crushing and hence could not be used in preparation of certain food products like corn-bread and tortillas. Also, the new strain was more vulnerable to fungal infections and insect infestations during storage. Efforts to commercialize 'Opaque 2', therefore, were not possible. The challenge to hybridize another new strain with the incorporation of the desirable genes of 'Opaque 2' was taken up by three scientists — Ernest Sprague, S.K. Vasal and Evangelina Villegas — of the International Maize and Wheat Improvement Centre in Mexico (CIMMYT).

The new strain, 'Quality Protein Maize' (QPM) was evolved by 1988. But unfortunately, this high-yielding and high-protein variant has not been welcomed by most countries mainly because the peasants are hesitant to switch over to something new from the well-known, older varieties (Brown1995).

11

Giants and Dwarfs of the Vegetable Kingdom

Some of the vegetable giants have an almost astronomical age when compared with the human span of life. The life period varies from species to species. For a layman the question is how to estimate the age of a tree. As a tree grows, it not only increases in height but its trunk becomes thicker as well. A tree can keep its own record of age by a series of annual growth rings that develop in its stem each year. When properly counted, these rings give a fairly accurate idea of the age of a tree. There is no other sure way of telling the age of a tree — neither by its height nor the thickness of its trunk. The only problem is, that to be able to count the rings, the tree must be cut down, and a cross-section of the stem should be made carefully. To save the giants amongst plants, scientists have devised a method. A systematic study of the annual rings can be correlated with the annular increase in girth of the stem. For this purpose a slender core of wood can be taken from a tree, from bark to the centre of the trunk, with the help of a borer so that no significant damage is caused to the tree.

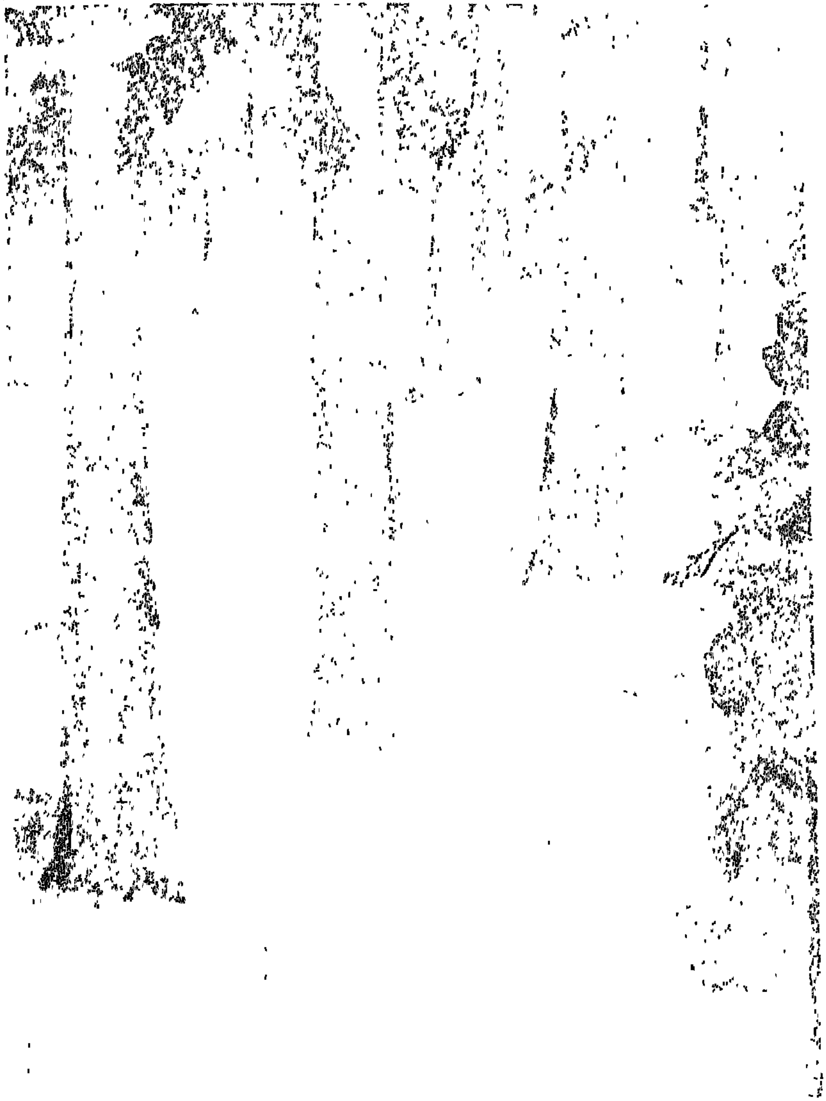


FIG. 11.1

Giant red-wood trees, *Sequoia sempervirens*. A drive through the pure stands of these giant trees.

The oldest known plants are not necessarily the largest. It is among the Cycads, the oldest plants are known to occur and they are by no means very large. According to Chamberlain (1903, see McCann 1959), a species of *Macrozamia,* a native of Australia, attains an age of 12,000 to 15,000 years, although some authorities do not support this observation (McCann 1959).

Some plants which attain such age are : Baobab — *Adansonia digitata* of Africa but cultivated in India (ca 5,150 years), *Sequoia gigantea* of America (4,000 to 5,000 years), *Ficus religiosa* (ca 2,000 to 3,000 years), *Cupressus sempervirens* (2,000 to 3,000 years), *Taxus baccata* (900 to 3,000 years), *Juniperus communis,* (ca 2,000 years), *Taxodium mexicana* (2,000 years), *Picea excelsa* (200 to 1,200 years), *Cedrus libani* (1,200 to 1,300 years), *Olea europaea* (800 to 1,000 years), *Quercus* species (500 to 1,000 years) and others.

These figures are insignificant when compared with the length of the family history of some of these trees. Fossil records show that *Sequoia* was flourishing 150-125 million years ago (during the Jurassic period) almost all over the Northern Hemisphere. Although they are now confined to a much smaller area on the Pacific coast of North America, they are still as vigorous. The generic name commemorates the great Cherokee Indian, Sequoya.

Sequoia sempervirens, (Figs. 11.1, 11.2 A, B), commonly known as 'red-wood', is a native of the fog belt of the Coast Ranges from Northern California to Southern Oregon in USA. It is amongst the tallest trees, often reaching a height of 300 ft (91 m) or more, and a trunk diameter of 15 ft (5 m) to 20 ft (6 m) above the swollen basal region. The red-wood has been used extensively for its timber in recent years. The timber is devoid of much resin and therefore considered to be 'fireproof'. The heart-wood is light-coloured, strong and durable as it resists the attacks of fungi, termites and other insects. The other species is the world-famous *Sequoia gigantea* or 'Big Tree'. They occur in scattered groves at altitudes of 3,000 to 8,500 ft on the western slope of Sierra Nevada, California, USA. Captain Joseph Walker mentioned this plant for the first time in his publication (1839) about the expedition he undertook in 1833. This species of *Sequoia* is not only the largest in both height and bulk but also reputed to be the oldest living tree. The counts from the largest stumps have shown the age to be 4,000 years; the usual life-span is about 2,000 years. The largest reported specimen of this plant was the 'General Sherman Tree' at Sequoia National Park, USA — about 272.4 ft (83m) tall and 101.5 ft (31 m) in circumference at the base. In the Underwood Park on the Red-wood Highway in USA, is a massive 'drive-through' tree (Fig. 11.2 B). Its diameter at the base is 21 ft and it reaches a height of 315 ft.

In Yosemite National Park in California, there are three *sequoia* groves and the largest of these is the Mariposa Grove. 'Grizzly Giant', the sequoia with a trunk almost 31 ft (9.5 m) in diameter and an estimated age of 2,700 years, is also growing in the Mariposa Grove (Scheffel and Wernert 1980). Its wood does not claim any commercial value and so has been spared by the axe-men.

Another tall tree is the Australian Gum tree. These are very fast-growing *Eucalyptus amygdalina*. The tallest specimen grew in Victoria and reached a height of 470 ft.

On the other hand, there are some dwarf willows (*Salix* spp). These are the smallest woody plants — a creeping alpine plant (*S herbacea*) seldom more than two inches above the ground; the catkins are minute with only a few flowers. Severe weather conditions have resulted in the formation of the dwarf oaks of Wistman's Wood on

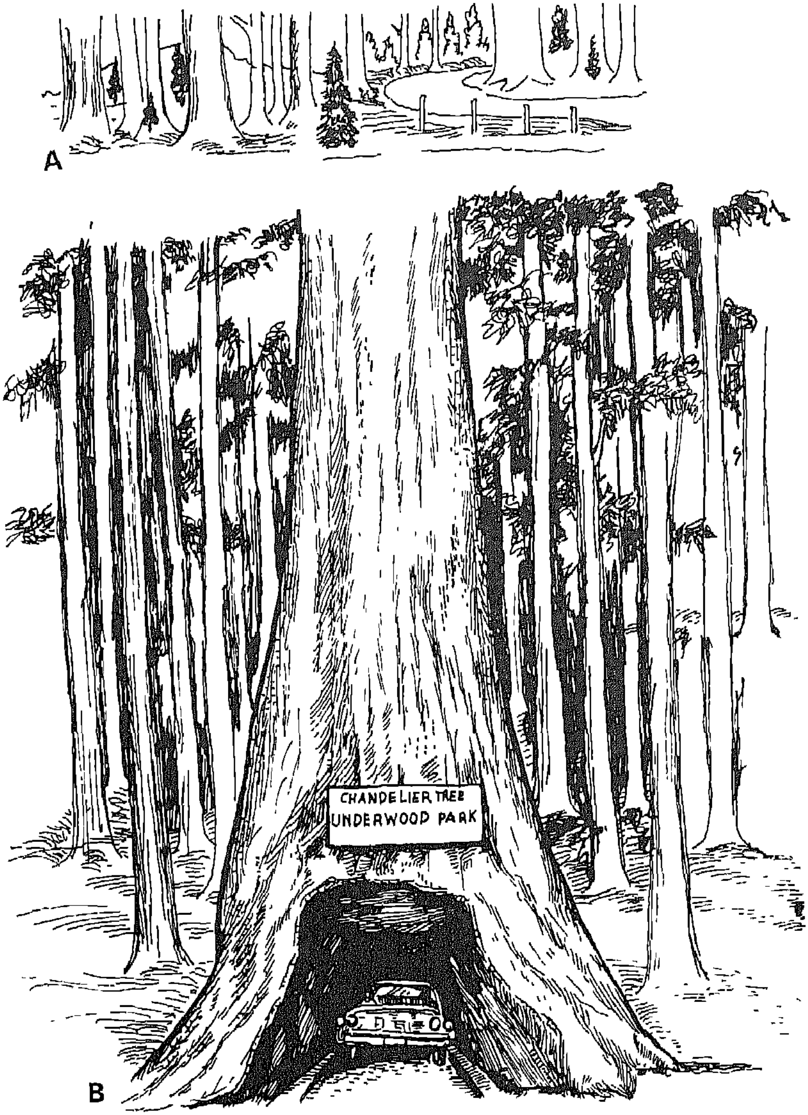


FIG. 11.2 A, B
Sequoia sempervirens *A* Landscape. *B* Drive-through tunnel at the base of the tree.

Dartmoor, UK (Wilson 1945). These plants have gnarled and twisted stems and though centuries old, are only a few feet high.

The smallest gymnosperm is *Zamia pygmaea* whose fronds are only five to seven cm long (Bhatnagar and Moitra 1995).

The smallest of all flowering plants is the tiny duckweed, *Wolffia microscopica*. Individual plants are very small (Fig 11.3), barely visible to the naked eye and a large mass of these may be mistaken for floating green algae. They usually grow in marshy places amongst the reeds. The body of the plant consists of a circular leaflike thallus or 'frond' near the basal margin of which are one or two reproductive pouches. This extremely reduced thalloid plant-body measures only about one-twentieth of an inch in length. The plants are without leaves and its flattened green stem acts as a leaf and performs its function. The unisexual flowers of only one or two stamens (staminate or male flower) or a single carpel (pistillate or female flower) are borne side by side on the dorsal flat surface of the plant body, inside a pouch. In the male flower the filament is stout bearing a pair of anther lobes at its tip. The pollen grains are warty and get easily stuck to the funnel-shaped stigma that secretes a sugary fluid. The female flower consists of a single carpel which is flask-shaped, has a funnel-shaped stigma and a unilocular ovary; the ovary includes one or more basal ovules. Pollination is by insects or water. Flowers, however, rarely develop and the plants multiply vegetatively.

There are a few more plants which are famous in different ways. One giant among the lower plants is a seaweed of the Brown algae group, *Macrocystis pyrifera*. It grows in the cold waters of the Pacific Ocean and has been known to reach a length of 1,500 ft (McCann 1959). There is a tough stem which reaches the surface of the sea and bears the long fronds. These fronds have air bladders so that the

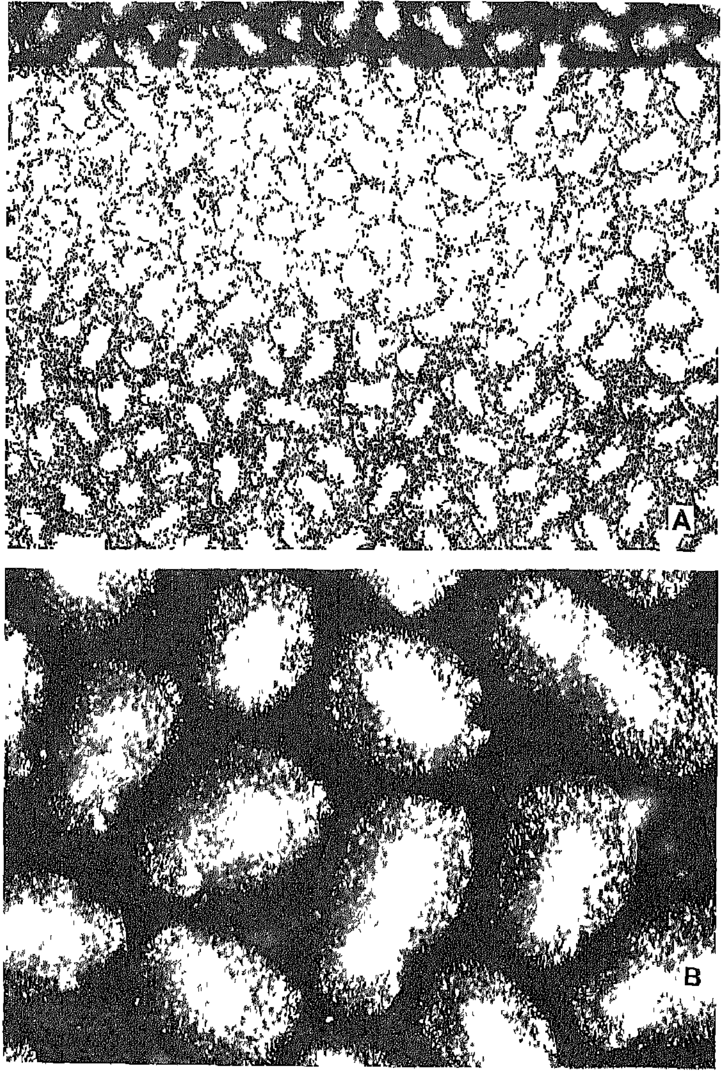


FIG. 11.3 A,B

Wolffia microscopica, the smallest angiosperm. *A* A colony of *Wolffia* plants. *B* Plants bearing flowers — the densely-white area in each plant (*Courtesy*: A. K. Tyagi) whole plant appears to be floating; on one occasion it was mistaken to be a sea-serpent.

Some plants are well-known for the girth of their stems. For example, *Castanea vulgaris,* the Chestnut tree, attains the maximum girth of 65 ft (20 m), *Taxodium mexicanum,* the Mexican Cedar, comes next with a girth of 52 ft (16.5 m). *Adansonia digitata,* the African Baobab, also attains a girth of almost this size.

The Great Banyan Tree (Fig. 11.4) of the Indian Botanical Garden as Sibpur, Howrah, in West Bengal, is about to complete 240 years of age. The tree is mentioned in the *Guinness Book of World Records* for its dimensions and number of prop roots. There are 1825 prop roots and the circumference of the canopy is 420 m. The area covered by this

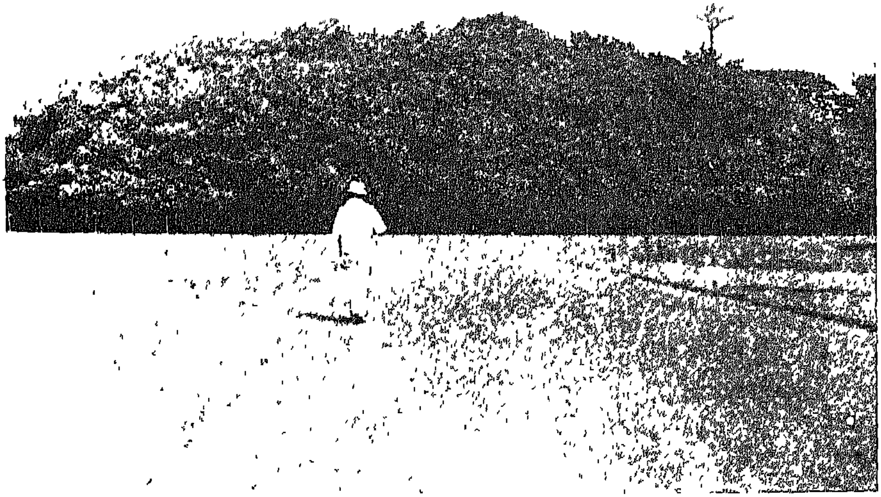


FIG. 11.4

The great Banyan tree, *Ficus benghalensis* (at the Indian Botanical Garden, Sibpur, Howrah).

tree is about 1.40 hectares and the length of the highest branch is 24.5 m.

Victoria amazonica is the magnificent giant water lily from northern South America. This plant is known to bear the largest leaf. A mature leaf has a diameter of six to seven ft. (1.8-2.1 m) and is so buoyant that it can support a weight of 100 to 200 lbs. These plants are often photographed with a child sitting on one of the leaves.

It may be very amusing, but the largest flower is borne by a parasitic plant, *Rafflesia arnoldii* (Fig 11.5). This is a plant from the tropical rain forests of Sumatra, named after its discoverer Sir Thomas Stamford Raffles, a British officer and naturalist.

In July 1818, the Royal Society of London decided to send three naturalists — Sir Stamford Raffles, Lady Raffles and Dr Joseph Arnold — to the tropical jungles of Sumatra in search of new and undiscovered plants. Once, when they were camping inside the thick forests, their servant-boy came running from the forest. It appeared as if he was struck by something very amazing and he was almost out of breath. He told Dr Arnold (who was available at that time in the camp), to accompany him so that he could show him the huge, big, beautiful and unusual flower in the forest floor. Dr Arnold accompanied the boy and saw the largest flower in the world for the first time. He plucked and brought this unusual flower with a fetid smell to the camping ground. But, he was so badly affected by the odour of the flower that he developed high fever and died within a short period. As he had seen elephant's dung near the flowers, he assumed its pollination to be carried out by this animal. Probably, he gave importance to the size of both the organisms ! However, this was proved wrong later on. It is the Carrion flies (attracted by the fetid smell) which bring about pollination.

In 1868, a sketch of this flower was published. It was named *Rafflesia arnoldii* by Robert Brown to honour Sir Stamford Raffles and Dr Joseph Arnold.

The sticky seeds of *R. arnoldii* germinate in the fissures on the bark of plants like *Tetrastigma* and *Vitis* and produce colourless, thin, thread-like strands that penetrate the stem to obtain nourishment. Soon after, the flower buds are formed. As there is no stem, root or leaf formation, the flowers appear to be springing from the roots or stems of the host plant. This largest-known flower is three ft in diameter and weighs 12 to 24 lbs; it remains open for five to seven days and emits a fetid odour of rotting meat which attracts the pollinating agents like the Carrion flies. Each flower, either male or

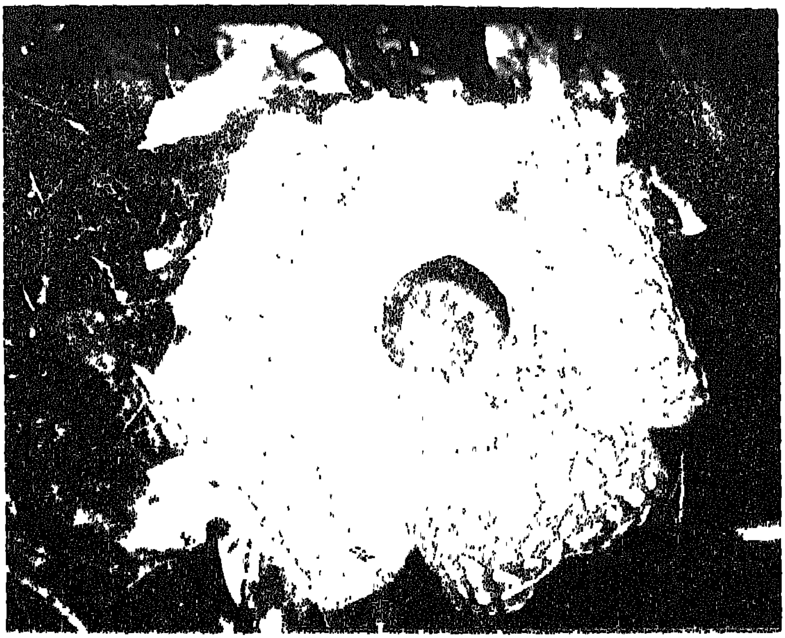


FIG. 11.5

Rafflesia arnoldii, the largest flower of the vegetable kingdom.

female, has five limp, fleshy, petal-like segments (calyx), coloured reddish or purplish-brown and, sometimes, mottled pink or yellow inside and with brownish or bluish scales on the exterior. The sex organs are formed inside a partially-covered central cup, coloured fiery-red. The fruit is a brown, rough-surfaced nut, enclosing innumerable seeds which are disseminated by fruit-eating rodents.

The Double Coconut tree — *Lodoicea seychellarum* of the Seychelles Islands — bears the largest fruit. A full-grown specimen is one metre in circumference and weighs about 11 kg. The tree must be at least 30 years old before bearing flowers and fruits and five years is the time required for maturation of these giant fruits. It also contains the largest seed weighing 27,000 gms. Details of this plant are given in Chapter 7 of Part I of this book.

Amorphophallus titanum, Titan arum, is the giant arum that bears a six feet high inflorescence. In their natural environment, the rain forests of Sumatra, they bloom every two or three years.

In August, 1878, Beccari had seen this plant in the State of Padang in Sumatra. According to him the whole inflorescence is so large and heavy that to transport it from one place to another, four persons have to carry it. A man standing nearby cannot reach its top, nor can it be encircled by two hands (Saxena 1993). Some of these were planted in the Botanical Conservatory in Florence, some in the Kew Gardens, and in 1932, at the New York Botanical Garden at Bronx.

A gigantic Titan arum blossomed at the Kew Gardens for the first time in 33 years on 29 July 1996. It emits a very unpleasant odour of rotting meat. According to Sir David Attenborough, a naturalist, "The smell of rotting flesh is at its strongest when it first opens. After a couple of days it diminishes." Peter Boyce, a botanist at Kew Gardens said: "On Tuesday night (30 July 1996), the smell of the bloom was quite overpowering around eight O'clock. It was a mixture of rotting flesh and burning sugar with ammonia over the top. It was a bit like a rubbish bin in summer time." Greg Redwood, manager of Garden Development at Kew, described this Tuesday night stink as disgusting — very much like rotten crabs .

Titan arums have bloomed only four times at Kew Gardens — in 1889, 1901, 1926 and 1963. Hence, botanists and curiosity-seekers were waiting from Monday, 29th July 1996 for this unusually tall (three metres) plant to bloom. In the last few days the inflorescence had been growing at an incredible rate — four to six inches (10 to 15 cm) per day. Hundreds of people thought it was worth waiting in a 500 m long queue to get into the conservatory and file through the hot, heavily misted jungle environment to see this wonder.

In Sumatra, this plant is known as the 'corpse flower'. Attenborough said that the (stinking) aroma is produced to attract the attention of the 'sweat bee', an insect that lives in the rainforest of Sumatra. Flowers are not designed to smell nice at the behest of man. Some flowers do smell good and that is because they are pollinated by 'honey bees'. These insects get entrapped in the space between the column-like inflorescence and the spathe covering it. The female flowers at the lower portion may get pollinated if the flies had paid an earlier visit to another inflorescence. The trapped flies are released only when the sheath or spathe withers away and, while doing so, they get dusted with pollen from the male flowers higher up on the column (Wilson 1945).

Another such magnificent inflorescence is borne by the Umbrella palm or Talipot palm, *Caryota umbraculifera*. At full maturity, its leaves become smaller in size and a huge flower bud about one metre in height is borne at the apex. Later, it bursts with a loud sound and unfolds into a lovely white blossom. The inflorescence appears as a majestic pyramid of thousands of cream-coloured flowers, almost to a height of six metres above the leafy crown. *Chisocheton paniculatus* (Meliaceae), a tree from north-eastern Himalayas bears one of the largest panicles.

Then there are the orchids with extremely small seeds. The orchids bear the most beautiful as well as complicated flowers, which may range in size from less than a sixteenth of an inch to more than a foot. The seeds are so small that up to 25,000 to 30,000 may weigh one gram. The terrestrial orchid, *Goodyera repens,* has the smallest seed weighing 0.000002 gm.

Lastly there are some seeds well-known for their longevity. Lotus seeds remain dormant for a prolonged period. Some of these were germinated by Robert Brown in 1848, after 237 years in dry storage. Some others, reported to have been dug from an ancient lake-bed in Manchuria also germinated and these are reported to be about, 1,040 years old (For a detailed account see the chapter, 'Sleeping Seeds, Awake').

One massive giant tree that grows beside the Cathedral at Santa Maria del Tule, near Oaxaca (Mexico) is 112 ft in circumference at its base. It is known as the 'Big Cypress of Tule', *Taxodium mucronatum.* It represents a dozen or more trees that sprang up as suckers from the roots of a fallen ancestral tree. Later on, all these separate suckers might have fused into a single inseparable edifice. Some presume this tree to be ca. 5,000 years old and that may not be incorrect looking at it from the point of view of its size and fusion amongst different crowns. Such a large tree requires an enormous quantity of water. People of Oaxaca did everything possible to ensure adequate supply of water for this famous landmark of their country.

Plants of the Palm family are no less important when we talk of size. Royal Palms, *Roystonea regia,* are 100 to 125 ft tall, Coconut Palms, *Cocos nucifera,* usually 60 to 100 ft tall, and the Oil Palms, *Elaeis guineensis,* 50 to 100 ft tall. *Raphia vinifera* does not have a very tall stem but its huge feather-like leaves are sometimes up to 65 ft in length (30 to 50 ft normal length).

Bamboos (including about 70 different genera) of the Grass family (Gramineae) are also very tall plants. They grow in almost all the tropical countries of the world. Amongst the South-East Asian countries, India and Japan have a rich flora of bamboos.

Dendrocalamus giganteus reaches up to a height of about 100 ft whereas the plants of *Dinochloa andamanica* can be as tall as 270 to 280 ft.

There are giants among the cacti also. The Old Saguaros, *Carnegiea gigantea,* are known as the 'Giant Cactus of Arizona'. These majestic cacti grow in the desert areas of California and Mexico and are often 30 to 50 ft tall.

12

Indigo

Life without colour is beyond imagination: the green meadows and 'blue' rivers are soothing to the eyes; a flash of yellow, red or orange flowers of the cacti is enchanting in the desert.

Vegetable dyes have been used since ancient times, in different parts of the world. Like spices, dyes also encouraged exploration of the far and near corners of the world and was responsible for the ups and downs of many Empires. The earliest record of the use of dyes has been discovered in the tomb-paintings of ancient Egypt (3000-2000 B.C.). The mummies in Egyptian tombs were wrapped in clothes that were dyed with colour from indigo (blue), maddar (red), and saffron (bright orange).

During the excavation of the city of Pompeii (which was devastated during the eruption of the volcano Vesuvius), dyers' shops stocked with dyes like fustic (*Chlorophora tinctoria*), cutch (*Uncaria gambir*) and weld (*Reseda luteola*) were discovered (Kochhar 1981). Besides spices, the camel caravans via Baghdad and Damascus carried dyes also to Europe from the East. Indigo was one of the important dyestuffs brought to the European markets during the sixteenth to eighteenth centuries by the merchants of Portugal, Holland and Britain. None of the

Europeans, however, was aware of the source of neel (indigo) and believed it to have come from mines. Though it is a fact that cultivated indigo plants were introduced into Europe during the fifteenth century, the botanical source of the dye remained unknown to them. In 1705 a British 'Patent' was granted for obtaining indigo from mines. The material was known to the ancients of Egypt, Greece and Rome, and according to Julius Caesar (in Shakespeare's play) the Britons obtained it from a plant named *Isatis tinctoria* (the woad plant).

The use of indigo was much resisted by the woad-producing countries, although it was already displacing woad in Italy. The influential woad-growers secured official permit for prohibition of the use of indigo all over Europe. In 1577, in an official declaration (in England) against indigo was "....prohibited under the severest penalties is the newly-invented, harmful, balefully devouring, pernicious, deceitful, eating and corrosive dye known as 'the devil's dye' .... used instead of woad" (Kochhar 1981).

At Nuremberg (West Germany) a law was enacted around the same time, by which the dyers had to take an oath that they would not use indigo. In spite of all these precautions, indigo did replace woad.

When Rome was at the peak of its prosperity, indigo was imported through Alexandria. As it was known to be of Indian origin, it was called 'Indicum' (P. Maheshwari 1965). In the sixth century, it was imported by China from India, through Persia. By 1200, indigo was also exported by sea-route from the West Coast of India and, by about 1652, its cultivation had spread to eastern Malaysia.

Indigo was obtained up to the last decade of the nineteenth century, from the plant *Indigofera*—*I. sumatrana*, *I. arrecta* and *I. tinctoria* of the family Fabaceae (= Papilionaceae). When the European traders came to India, indigo was cultivated in the western and southern parts and major shipments were exported from Surat. The Portuguese took indigo to Lisbon and sold it to the dyers of Holland. Up to the beginning of the twentieth century, the cultivation of indigo plant and extraction of the dye was an important industry in India. In 1897, 1,750,000 acres of land (in India) was under indigo cultivation, and about 17,000,000 lbs of indigo were exported. Due to its increasing demand, the Spanish, French, Portuguese and English tried to cultivate these plants in different countries outside India. There was much improvement in the cultivation and processing of indigo in countries like the West Indies and the southern states of America. Therefore, the Indian product was not favoured much, and the British East India Company gave up the indigo trade for a while. But, in no time, the Americans found coffee and sugarcane to be more lucrative crops, and stopped growing indigo. Indian indigo came to the frontline for the second time, and was re-established in the State (Province) of Bengal (undivided Bengal). From 1815 onwards, Bengal was the sole supplier of indigo for the whole world.

In the beginning, the British East India Company was looking after the cultivation as well as trade of indigo. But, soon, many of its employees started growing indigo on their own, and were so successful that they resigned from the Company's service. This was most unfortunate for the peasants. In order to make as much profit as possible, the planters (of British origin) subjected the poor peasants to inhuman treatment. They were not allowed to grow any grains or other food-crops on their land. Forcibly, they were made to cultivate only indigo. This oppression meted out to the farmers of Bengal and Bihar was paralleled only by the negro-slavery in America. In 1860, Dinabandhu Mitra, an upright man from Bengal, wrote the play *Neeldarpan* in which the life of four million cultivators (under the

British landlords) was focussed. This book did a great service in awakening public opinion. In a way it was comparable with another famous book, *Uncle Tom's Cabin*, by H.B. Stowe (1852), on behalf of the negro slaves in the cotton and sugarcane plantations of the southern states of America.

Indigo occurs in the form of colourless glucoside, indican, $C_{14}H_{17}NO_6$, H_2O in the *Indigofera* and *Isatis* plants, and is readily soluble in water. By a process similar to fermentation, the glucoside is split into glucose and indoxyl, C_8H_7NO — a colourless substance. By mild oxidation, even by air, two molecules of indoxyl are converted (by the loss of 4 H atoms) into indigo — $C_{16}H_{10}O_2N_2$ — a dark blue powder.

To obtain the dye, freshly cut plants are crushed and left for fermentation for 10-15 hours in specially designed vats.

It is reported that the addition of woad leaves enhances the fermentation process, as these contain the particular enzyme for conversion of insoluble 'indigotine' to 'indigo white'. Next, the yellowish solution is passed through oxidizing vats. These vats are provided with paddle-wheels and by their movement the liquid is continuously stirred to bring about oxidization. As soon as the blue colour develops, stirring is stopped. Insoluble blue indigo now settles at the bottom of these vats and appears like bluish mud. The supernatant fluid is drawn off, and the bluish 'mud' is treated with boiling water, for further granulation. Lime water is sometimes used instead of boiling water alone. The granulated indigo is now filtered, pressed, cut into small cubes and then air-dried. This is now the commercial indigo.

With the advent of synthetic dyes, the use of natural indigo declined. A young scientist, William Henry Perkin of London, discovered the coal-tar dyes in 1856, when he accidentally oxidized aniline, a coal-tar derivative. In 1883, the German chemist, A. von

Baeyer, and his pupils, announced the chemical constitution of indigo. Germany now had the capacity to manufacture indigo from coal-tar and, in 1897, its manufacture was achieved on a commercial scale. Synthetic indigo soon became most sought after. It was cheap and could be obtained on a regular basis.

With the outbreak of World War I, the scenario of indigo trade changed again. The dye from Germany was no more available and sale of indigo from Calcutta was resumed in December 1914. Once again countries like India, Java, China and Japan started growing indigo plants. In 1916 - 17 the area under indigo cultivation increased manyfold. Once again the heavy hands of the British landlords came over the poor peasants. They started collecting all the taxes and 'begar' (forced labour) from the poor farmers who had taken their lands on lease.

The farmers were compelled to grow indigo on a fixed proportion of the land they rented, and this was never less than three-twentieth of its area. This was the notorious *'teen-kathiya'* system. The (British) planters fixed their own price for the crop and the labour they hired were given the lowest wages possible — 10 pice (then 100 pice = 1 rupee) for a man, six pice for a woman, and three pice for a child working for 11 to 12 hours a day.

After the end of World War I, Germany again started manufacturing synthetic indigo and natural indigo never regained its importance.

13

Mosses, Mosses All the Way

EVERYONE can recognize moss although the individual plants are small and rather inconspicuous (Fig. 13.1). During and after the ains, and in the winter months, mosses grow in almost every shady, ioist nook and corner — on the tiles of roofs, moist shady corners of iwns, in the crevices of the bark of trees, forming extensive green arpets.

There are about 15,000 different species of mosses which grow ll over the world, vary extensively in size and shape of both the leafy hoots and capsules. The largest member amongst the mosses is *awsonia* from Australasia, with shoots growing commonly up to 20 m high but sometimes even up to 70 cm high under ideal conditions i wet shady forests. The smallest amongst the mosses is *Ephemerum* hich may be less that half-a-millimetre high. Although most mosses re terrestrial, some may be epiphytic but rarely aquatic such as *ontinalis*, common in the Northern Hemisphere and almost as large s *Dawsonia*.

Some mosses have a remarkable ability to revive after prolonged lesiccation. They can even be revived from the dry herbarium specimens; *Anoectangium compactum* can survive desiccation and retain viability for 19 years, *Grimmia elatior* for five years, and *Bryum argenteum* for about two years (Richardson 1981).

Some interesting facts about mosses have been revealed from archaeological studies too. From the excavations at Vindolanda, the site of a Roman fort in Northern England, south of Hadrians Wall, it is known that the people who lived there between A.D. 90-120 covered the floors of their dwellings with thick layers of bracken fern, straw and moss. The two main groups of mosses were *Hyloconium splendens* and *Rhytidiadelphus squarrosus* (Seaward and Williams 1976).

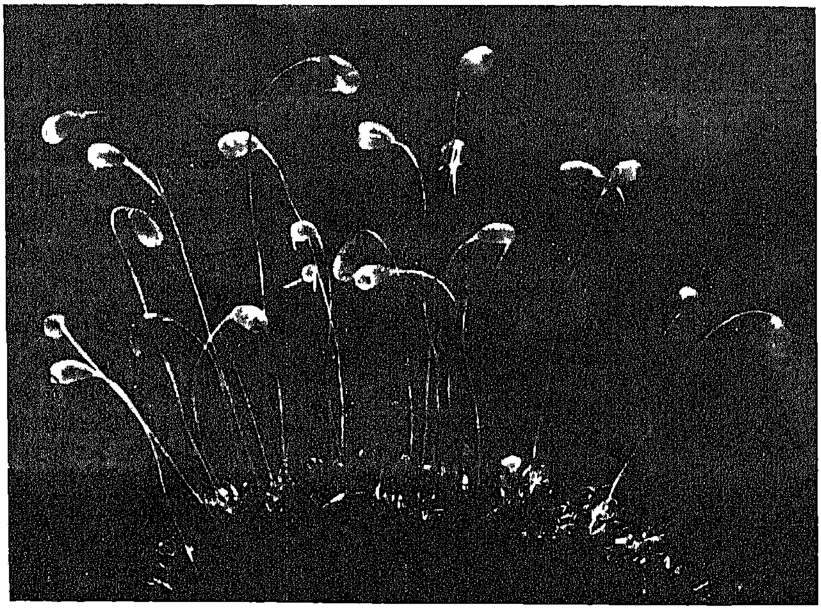


FIG 13.1

Funaria hygrometrica, plants with mature capsules; one of the very common mosses.

Pits, lined carefully with various moss species (*Pleurozium schreberi*, *Hypnum cupressiforme* and *Hyloconium splendens*) have been discovered in another archaeological site at York, England (A.D. 1200). These pits were probably used for storing fresh vegetables and fruits (Seaward and Williams 1976). Moss had also been used as a filling material between the planks of boats to make them water-tight during the Bronze Age (800 B.C.) and Iron Age (200 B.C.) (Dickson 1973).

An interesting episode is that of the Tyrolean Iceman. An analysis of the mosses and liverworts from the excavation site and clothing of the Tyrolean Iceman suggests that he moved from the south of the Alps to his place of death.

The Iceman lay frozen for more than 5,000 years in an ice-filled rock hollow near Hauslabjoch in the Otztal Alps (Italy/Austria) at 3,210 metres above sea-level. His body was removed in September 1991 and a number of mosses and liverworts (fragmentary) were recovered from the site itself and his clothings: fur-leggings, jacket and cap as well as the cape. These mosses included *Polytrichum piliferum*, *Pohlia* spp., *Andraea* sp., *Rhacomitrium lanuginosum*, *Polytrichum sexangulare* *Neckera complanata*, *N. crispa* and *Pleurozium schreberi*. Of these *Neckera* spp. were used for various domestic purposes like packing and insulation, and could have been brought by the Iceman himself. Others like *Hyloconium splendens* and *Pleurozium schreberi* grew abundantly in the forest floor of Spruce-Larch woodland and might have got attached to the clothes of the Iceman accidentally (Dickson et al. 1996).

Neither Theophrastus (300 B.C.) nor Dioscorides (first century A.D.) ever mentioned mosses in their writings. But in some of the early herbals, e.g. *Niewe Herball* (1576), *Polytrichum* has been mentioned and illustrated. Its English names are the 'Golden

FIG. 13.2
Polytrichum commune, its hairy calyptra covering the capsule gives the common name 'hairy-cap moss'.

Maidenhair Moss' or the 'Hairy-cap Moss' (Fig. 13.2). The shoots of this moss were up to 30 cm long and tough, pliable strands could be obtained when the leaves were removed; the strands could be plaited into braids. An unfinished basket of this moss material dated around 90 A.D. has been discovered in well-preserved condition at Newstead Abbey, Scotland. In Holland and in northern Scotland, moss was used in construction of boats during the sixteenth and early nineteenth centuries, respectively, Linnaeus reported that *Pleurozium schreben* was used to block spaces in the walls of the wooden houses in Scandinavia, to keep them warm within. This practice is still common in the construction of log-houses in Russia.

What is the significance of the specific epithet of the aquatic moss *Fontinalis antipyretica*? In different parts of Europe, the spaces between the chimneys and the walls were filled up with this moss to exclude air and thus prevent the walls from catching fire. '*Antipyretica*' means 'against fire'. However, some people presume that the moss itself does not catch fire.

In England the less well-off citizens used *Polytrichum* and *Hypnum* for stuffing mattresses and pillows, respectively. While in Scandinavia, Linnaeus was overwhelmed using bed and bedding made of *Polytrichum*. The Scandinavians folded their bed tying it with a cord, and carried it to the place where they would sleep at night. If this bed was too dry and compressed, its former condition could be regained by just sprinkling it with a little water.

The Indians of North America used *Dicranum bonjeanii* as an absorbent and *D. elongatum* for lamp wicks. A paste made from *Philonotis, Bryum, Mnium* and some other mosses were used as a poultice to reduce the pains of burns. Mosses were also used for padding under-splints for setting bones in case of fracture by the Gosuite Indians of Utah (Flowers 1957). The Inuit of North America not only used *Rhacomitrium lanuginosum* for making lamp wicks but also made beds for burial of their dead (Thieret 1956).

The ladies of Boston, USA (around 1900) had their hats and bonnets trimed with imported braids and cords made of moss. Braids were made from *Pseudoscleropodium*, and cords from *Neckera crispa*. As we buy flowers from the florists today, in New York around 1900, one could purchase bunches of *Climacium dendroides* and moss roses of *Hyloconium splendens*. The natives of New Guinea used various mosses in their head-dresses for certain ceremonial occasions. In the Victorian period (early nineteenth century), the mosses (after cleaning) were used for various purposes : for covering the surface of soil in potted plants so that the soil did not dry up quickly, in flower arrangements and for trimming ladies' bonnets, sometimes even after dyeing them. Of course, the bryologists of England did not advocate the last use of the mosses !

Mosses can also inspire some people psychologically. It is said that once an African explorer, Mungo Park, was captured by the Arabs but he managed to escape after four months. While escaping, all his belongings, including the compass, were stolen, he had fever and was hungry. When he was almost on the verge of death, his eyes caught sight of a small insignificant moss in fructification. He got the inspiration to remain alive as he realized that God was concerned about everyone be it a moss or a human being.

Mosses have aesthetic value too. Maximum refinement in the cultivation of mosses is practised in Japan. Suitable rocks and trees are selected by landscape gardeners and mosses are planted in between. This gives a very soothing effect.

Popular with amateurs, moss gardens are more common in temperate, shady and moist places. The most famous moss garden is in Kyoto Province in Central Japan. It has been planted in the temple grounds at Saihoji, and the temple is known as the 'Moss Temple'. About 50 species of moss grow here luxuriously, because of a comparatively high water table, high humidity, and moderate light intensity. *Polytrichum* is suitable for open areas whereas *Rhizogonium* and *Mnium* grow well in shady, moist areas and form a beautiful soft carpet; *Leucobryum* and *Bazzania* are grown under trees. *Brachythecium* can resist occasional tramplings and forms a whitish-green belt on the two sides of a path. The Japanese regard moss gardens as something unique. More than 60,000 people visited a special exhibition of mosses held at the National Science Museum in Tokyo (Inone 1972, Ando 1980).

In India, a Garden of Bryophytes was developed by the late Ms Giribala Pant at Nainital. The idea of a Bryophyte Garden at Nainital was initiated by the Programme Advisory Committee (PAC) on Plant Sciences, Department of Science and Technology, Government of India, New Delhi, under the chairmanship of Professor H.Y. Mohan Ram, for the protection and conservation of the endangered and threatened species of bryophytes, so that this unique Himalayan wealth and 'blocks of bio-diversity' are not lost forever.

These small, elegant but hardy green plants form a striking part of the Himalayan scenario. Their conservation should be given priority in any programme of environmental strategy. These 'Lilliputs of the plant kingdom' impart a beautiful lush-green appearance to rock surfaces, slopes, hillsides, tree trunks, forest floors and even spring or stream beds. There is every possible shade of green mixed with pale yellows, browns and reds. They spread in every nook and corner, occupying all conceivable habitats. They are the builders of soil, early colonizers, have good water-holding capacity and decrease surface run-off and act as 'nutrient sinks'. Mosses play a very important role in the mountainous ecosystem.

But, unfortunately, human (mis)behaviour is leading to its continuous disappearance. Pressures of urbanization, habitat-destruction, deforestation and pollution are only some of them. In addition, there is commercial exploitation as the mosses are used in making moss-sticks and moss-pots to decorate gardens in the plains. Last, but not the least, is the collection of moss specimens by students of Botany who collect less but spoil more. And then there are misgivings. To quote a senior forest officer at Dalhousie: "You take as much of it (moss) as you want; it will grow again. The fact is that in the process of uprooting the mosses, one may be destroying a number of rare or threatened species and one would not even know about it".

It was due to these reasons that the idea of making a 'Bryophyte Garden' was planned. A few instructions were laid down for consideration:

(i) Positioning of the components appropriately to improve the type of natural landscape of the selected area and to convert it into a bryophyte garden.

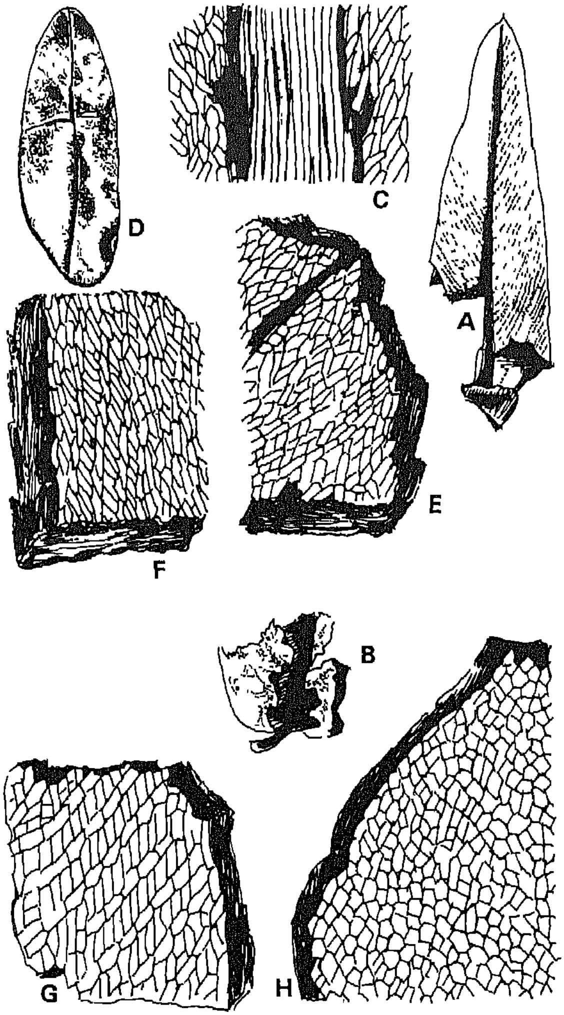


FIG. 13.3 A-H

A-F Fossilized leaves of ***Polyssaevia spinufolia*** from the upper Palaeozoic (270-225 million years) strata in Russia. It is related to the living moss ***Mnium***. *G, H* ***Protosphagnum nervatum*** with characteristics of the extant peat moss, ***Sphagnum***.

(ii) Setting-up moss-liverwort patterns and development of exclusive moss expansions.

(iii) Conservation of endangered, monotypic, endemic species either by transplantation or by 'creating' their natural habitat.

(iv) Development of rockeries with a preponderance of moss-hepatic associations.

(v) Transplantation of selected, hanging moss festoons on trunks and branches of shrubs and trees.

(vi) Maintenance of Bryoflora on the retaining walls in or around the garden by weeding out the undesired elements (grasses, herbs) and by allowing only the bryophytic elements to propagate.

(vii) Transportation of moss-covered stones, rocks or boulders from wilderness areas of bryophytic luxuriance to the garden site and their arrangement in a desired pattern.

(viii)The distinct habitat preferences shown by the bryophytes have been taken advantage of by 'creating' different habitats and propagating the selective species therein.

Ms Giribala Pant endeavoured to develop a 'Bryophyte Garden' in which rare and endangered species of this plant group are being grown and multiplied for research and educational purposes. This experimental Moss/Bryophyte Garden came into existence in 1991-92 in the Department of Botany, DSB College, Kumaon University, Nainital.

The fossil history of mosses is quite substantial. Well-preserved material is widespread. Fossilized moss leaves (Fig. 13.3 A-F) have been discovered from the upper Palaeozoic (270-225 million years) strata in Russia (formerly, USSR). This fossil moss, *Polyssaevia spinufolia,* is related to the extant true moss *Mnium*. The most ancient fossil moss is *Muscites polytrichaceus* from the upper Carboniferous (350-270 million years) deposits in France, and is about 320 million years old. Three species of *Sphagnum*-like plants have been reported from the rocks of the Permian age (270-225 million years). *Protosphagnum nervatum* (Fig. 13.3 G,H) is one of them. Some other members of the *Sphagnum*-like genus have been discovered in Tertiary (70-50 million years) and Quarternary (2.5 million years) deposits also (most recent in the Cenozoic period).

14

Peat

Peat is a deposit of decayed vegetation in the bogs and swamps which abound in bog-moss *(Sphagnum,* Fig. 14.1). Peat deposits occur mainly in temperate countries—in Russia (formerly USSR), 65,000 sq. miles area; in Canada, 37,000 sq. miles; in Finland, 30,000 sq. miles; in Sweden, 19,000 sq. miles, and in the United States of America, 11,200 sq. miles. Sometimes they occur even at sea-level in tropical countries like Guinea and Trinidad.

The plants that take part in the formation of such deposits are mainly aquatic grasses, e.g. *Molinia caerulea* (the blue moor grass); sedges, e.g. *Trichophorum caespitosum* (the deer's hair sedge), and mosses such as *Sphagnum* spp (the bog-moss). In Irish peat, the moss *Rhacomitrium lanuginosum* is dominant.

Peat accumulates where the soil is wet enough to keep down oxidation. Disintegration of the vegetable tissues is only partial — partly affected by moist atmospheric oxidation and partly by anaerobic bacteria, yeasts, molds and fungi. Peat is usually formed in depressions containing fairly still but not stagnant water which is retained by an impervious bed, or underlying strata, or where water drips along rocky slopes. As partial decomposition proceeds, the products sink to the bottom of the swamp. In course of time, the lower layers of the deposits become compressed and carbonized because of the pressure of water and later deposits. In cool, rainy areas the soil remains moist because of abundant rain and low evaporation, and peat forms on the slopes. These hill peats are called 'climatic-moors' because the moistening is due to the climate. Where the water is acidic, the peats which receive only rain water and support mainly *Sphagnum* moss gradually build up until their centres are higher than their margins. These are called 'hochmoors'.

When established on the shores of lakes, it gradually encroaches

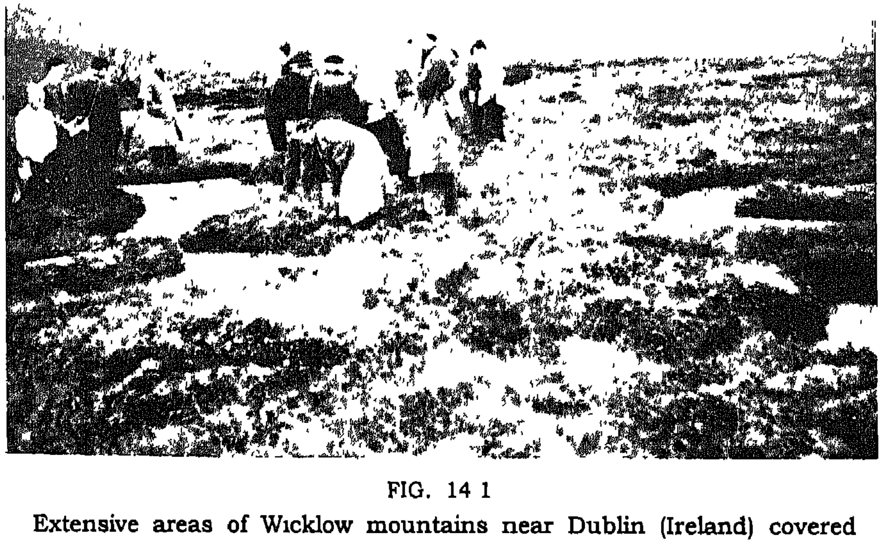


FIG. 14 1

Extensive areas of Wicklow mountains near Dublin (Ireland) covered with 'peat' bogs. The water in between the *Sphagnum* masses is acidic Some members of the British Association for the Advancement of Science are botanizing. (*Courtesy.* B.M. Johri).

more area of water as 'creeping bogs' and may ultimately cover the lake completely in course of time.

Peat varies from a pale yellow or brown fibrous substance resembling turf or compressed hay containing conspicuous plant remains, to a dark-brown compact material resembling black clay when wet and some varieties of lignite when dry.

As wet, acidic soils have a somewhat preservative property, intact logs and even well-preserved human bodies have been discovered almost after a century in bog water, with the original structure of the tissues intact.

Peat is economically very important. In Britain, tenders are invited by the Forestry Commission for collecting the fresh bog-moss (*Sphagnum*) from the areas within its jurisdiction. Applicants increase in number particularly before Christmas and in the spring. The moss, after collection, is cleaned and extra water is squeezed out from it. *Sphagnum* in this from is used to line hanging baskets, for floral displays specially in flower and horticultural shows.

Dried *Sphagnum* is used as packing material for delicate plant materials (living) to be sent long-distance. In various nurseries, the moss is used for aerial rooting for the purpose of propagation. It is also used to pack frogs, worms and some insects for sending them from laboratory-supply-houses to schools and colleges.

That the dried *Sphagnum* moss can be used as absorbent dressing has been known for centuries. In the British Isles, country people used it for treating boils and discharging wounds (Richardson 1981). *Sphagnum*-dressings were used on a large scale during the Russo-Japanese war of 1904-1905 (Thieret 1956). During the First World War also *Sphagnum* dressings proved useful. It is reported that the British used a million dressings a month, and the Germans probably more. Americans, however, did not like this type of dressing unless it was covered with a thin layer of cotton (Hotson 1921 a,b). The advantages of *Sphagnum* dressing are:

(i) It absorbs 16- to 20-times its own dry weight of liquid, whereas cotton dressings absorb only four- to six-times.

(ii) The *Sphagnum* dressings remain cool and soothing as the bog-moss is porous.

(iii) The dressings are antiseptic and do not require frequent changing so that the soldiers could be shifted from the field to the hospitals without further infection during dressing changes.

(iv) *Sphagnum* has mild antiseptic properties which cotton does not have.

When the First World War ended in 1918, factories were established in Germany, UK, USA and Canada for the production of *Sphagnum* dressings. Cleaned and dried *Sphagnum* was enclosed in a layer of fine muslin cloth, the edges were stitched up and then sterilized. But soon, *Sphagnum* dressings were forgotton. The collection of moss required much expenditure which became a prohibitory factor. Also, white cotton dressing held greater aesthetic appeal to the patient and the doctor alike. The Second World War followed in 1940, but cotton was available in plenty and there was no need to revive *Sphagnum* dressings.

There are a few other uses of *Sphagnum.*

(i) In China a decoction of dried *Sphagnum* moss is reported to be effective in the treatment of haemorrhages and eye diseases.

(ii) In place of socks the Eskimos traditionally use this moss to pad their sealskin shoes.

(iii) An interesting use is mentioned by Linnaeus :

> Lapland matrons are well-acquainted with this moss. They dry and lay it in their childrens' cradles to supply the place of bed, bolster and even covering, and being changed night and morning it keeps the infant remarkably clean, dry and warm. It is sufficiently soft by itself but the tender mother, not satisfied with it, frequently covers the moss with the downy hairs of reindeer, and by that makes the delicate nest for the new-born babe (Crum 1973).

The people of Alaska and around Hudson's Bay, Canada, also used this moss for the same purpose.

(iv) During the First World War, large pillows stuffed with *Sphagnum* were used for giving support to the injured limbs of wounded soldiers to make their travel more comfortable.

The maximal growth of the *Sphagnum* species occurs during the summer months. The average rate of peat accumulation is between 20 cm to 80 cm per 1,000 years.

The acidic medium and anaerobic condition ensures extremely slow rate of microbial degradation of buried organic materials. Such organisms which might have been trapped in the peat, do not show any decomposition.

About 700 or so corpses have been recovered from Scandinavian peat bogs. These are Iron- and Bronze-age human corpses. In some of these the skin, and the clothes worn by them are preserved and the stomach contents can be analyzed. Most of them were strangled with cords of braided leather, probably for sacrificial ceremonies.

The practice of throwing bodies in *Sphagnum* bogs was quite popular in ancient times, as is understood from the writings of Tacitus, the Roman historian, shortly before A.D.100.

Tacitus records that in the German tribes: "the traitors and deserters were hanged on trees; but cowards, shirkers and the unnaturally vicious were drowned in murky swamps."

Another legend is that the body of King Abel buried in the Schleswig Cathedral in 1252, would not lie quiet because he had murdered his brother. His body was then dug up and reburied in a peat-bog near Gottorp. This stopped his uneasy ghost from causing any further disturbances.

Apart from this, plants and animals also remain well-preserved in *Sphagnum* bogs. Most genera and sometimes species of plants have characteristic pollen grains. From the analysis of peat samples, it may be assessed or assumed what plants were growing around the bog (under study) at a particular time. The time-scale can be determined by radio-carbon-dating of wood fragments trapped at various levels.

The dried peat is.valuable as fuel and has been known in northern Europe from ancient times. The usual technique has been to drain a bog by digging trenches. Then small parts of peat are cut out with the help of a spade and placed on the top of the bog close-by. After drying these small blocks of peat partially, these are transported to the villages and towns to be used whenever required. Peat has a calorific value of about 3,300 cal/kg — about half that of coal but much more than wood.

In UK alone, the use of peat for purposes other than fuel had doubled between 1890 and 1895 (about 100,000 tonnes per year). Most of it was used as stable bedding. The 'red sphagnum' contained a fibre which after removal could be used in making surgical dressings. It is said that 12,000 kg of such dressings were sent for use by the French army during their expeditions to Madagascar between 1885 and 1896. Cloth could also be woven from the 'peat-wool' and a dress of this material was purchased by Her Royal Highness, the Duchess of York. There were many other products like insulation for refrigerators, paper and peat briquettes from peat, available but none of these was commercially successful.

The ecologists, all over the world have, however, voiced their concern against exploitation of peat. This leads to the destruction of not only the various species of *Sphagnum*, but also the associated flowering plants. The disappearance of all the species of *Sphagnum* (except the resistant *S. recurvum*) from the Pennine Upland mires in England is probably due to this (Ferguson et al. 1978). It is to be ensured that the energy-hungry man of today does not do away with the peat areas.

15

Bonsai

IN the fourth century A.D., the Chinese poet and civil servant Guenming was famous for his love of plants and flowers. It is said that when he retired from his official occupation, he started growing chrysanthemums in pots and decorated his house with the potted plants. Probably this was the beginning of growing plants in pots. About 200 years later, a new art using novel techniques developed from this 'pot-culture'. Paintings from T'ang dynasty (A.D. 618-906) depict pine trees, cypresses, plums, bamboos and some other plants growing in pots.

However, it was the Japanese who spent many years developing the technique and brought perfection to this new art of growing miniature plants in the form and shape of their larger natural counterparts (Fig. 15.1 A,B). To this they gave the name 'bonsai' where '*bon*' means pot or shallow container, and '*sai*' means tree. The height of the bonsai plants is usually 20 to 70 cm (eight to 28 in). In Japan, the history of bonsai culture goes back to 1309, recorded on a picture scroll by Takakana Takashina known as 'Kasugagogengenki', during the Kamakura period (A.D. 1180-1333). It is said that the aristocratic citizens used to display their prized possession of bonsai in decorative ceramic pots on the porticoes of their houses.

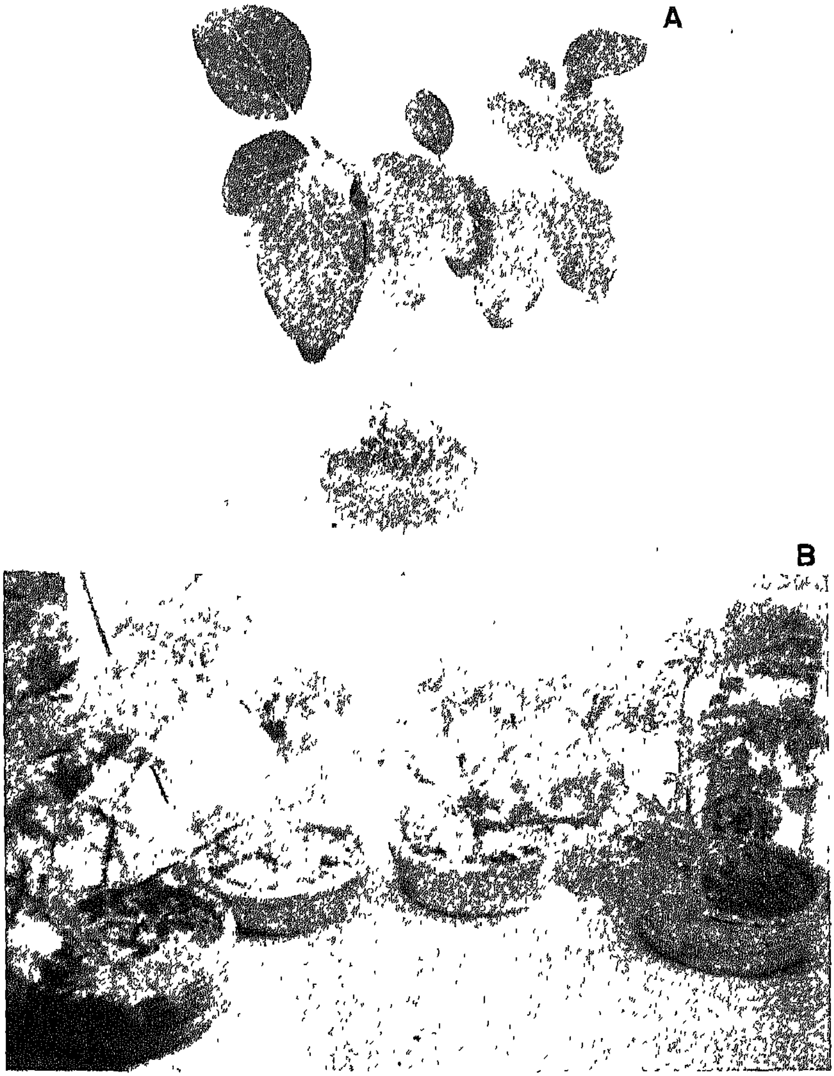


FIG. 15.1 A,B

A Twenty-five-year-old bonsai of *Ficus benghalensis*. *B* Bonsai, the dwarfed plants of the Japanese. (*Courtesy* : J. Chakrabarty)

By the fourteenth century, more people became interested in this new art. Bonsai of many young trees were made (to meet the public demand) by bending and tying their stems with a strong string (mostly of hemp, i.e. *Cannabis*) so that the height of the tree was reduced. Sometimes, an abnormal gnarled appearance was the result. This method came to be known as 'tako' and this style continued for a long time.

Along with the changes in the history of Japan, there have been changes in the styles of bonsai. During the period of considerable peace (Tokugawa period, A.D. 1603-1867), 'Literati' style bonsai was developed. These bonsai had a slim and trim stem, often tendriller (but strong) with a crown of branches and leaves occupying a small area. According to the artists of the Southern School of Chinese landscape painting, such a bonsai portrays one's search for 'freedom of expression'.

Up till 1820, the containers used for bonsai were deeper, but 1830 onwards shallow pots were used. The 'tako' style was not in fashion and, therefore, not much in demand after sometime. Naturally-dwarfed plants collected from mountains were the most sought after as they are now. The liberated Japanese society (after the fall of the feudal government in 1867) took more interest in this new art-form which was earlier the monopoly of wealthy citizens only. So much so, that by the beginning of the twentieth century they started exporting bonsai to the Western world and the first exhibition of Japanase bonsai in London was arranged in the year 1909.

A famous fifteenth century Japanese play tells us of a samurai who burnt his favourite bonsai to warm the hands of a stranger visiting him on a cold winter night. The Japanese regarded this act as an extreme sacrifice a man could make. The incident (although narrated in a play) reflects their great love for these diminutive trees and shrubs.

Bonsai is the art of dwarfing a tree or a shrub by confining it to a small pot or tray and systematically pruning its roots and branches (Perl 1979) to impart to it an appearance of age. A fairly good basic skill in horticulture, an artistic bent of mind, and a good perception are enough to create a bonsai. The plants used for dwarfed growth are herbaceous as well as woody, tropical as well as temperate. These may be artificially dwarfed, naturally dwarfed, or cuttings may be taken from dwarfed trees. Some plants by nature — are so slow to grow that they attain only a few inches height in a considerable number of years. It is presumed that such natural miniature plants have originated by the same method as the alpine plants. Some of these natural dwarfs grow in highly exposed places tolerating the adverse climatic conditions, sometimes between cracks in the rocks where they have been starved and dwarfed by nature (Ashberry 1967). Cuttings from such dwarfed trees grow like the parents and develop into miniature trees, when grown under similar conditions. These were the earliest bonsai.

In the beginning, these naturally dwarfed plants were left in their natural shapes. However, during the Ming dynasty (1368-1644), regional styles of bonsai developed. Trainees learnt how to create bonsai of 'flat top' and 'pagoda' types and many others. But, at present, these training methods are not practised any more and the Cantonese 'grow and clip' method gained prominence in the early twentieth century.

In tropical countries like China, Taiwan, Thailand, Singapore and Honkong, bonsai specimens are grown from some of the decorative house-plants like fig trees, and bougainvillaeas (Lesniewicz 1985).

Many tropical plants like *Ficus benghalensis, F. religiosa, Lantana camara, Casuarina equisetifolia, Punica granatum* and some others do well as miniatures.

The people of the Orient follow Zen Buddhist principles for shaping bonsais. The aim is to create something natural, simple and not symmetrical and to concentrate on something that is essential. Zen Buddhists look for harmony between man and nature, and regard the bonsai as religious objects that help in meditation (Lesniewiez 1985).

It is also reported that the followers of Taoism in China believed that natural phenomena like mountains, rocks, trees and plants contained certain 'magic' in them and that the smaller the forms, the more potent (concentrated) would be the 'magic'. Also, a contorted, gnarled shape (as is usual in many bonsai) was supposed to represent those who were in the world beyond mortality and had attained great age (Swinton 1996).

How does one 'make' (train) a bonsai ? A tree or shrub is grown in a shallow tray or pot. Its roots and branches are pruned systematically to keep it in a dwarfed stage. Any not-too-woody plant can be dwarfed by training. Harmonious effect of branches, leaves, flowers and fruits can be brought out on plants with delicate flowers and small fruits. The miniature trees are not shaped by genetic changes and, hence, there is no control upon the size of flowers and fruits. That is why, it is easy to train a woody tree with small fruits, such as 'dwarf orange' trees.

The idea that all bonsai are very old is incorrect. Even a comparatively young tree can be made to look old by the above techinque. For example, if in one such tree, the branches are shortened, the stem will appear thicker and therefore old. The same effect can be produced if the branches are bent downwards instead of upwards. Removal of bark from some places on the stem or exposing the surface roots at the basal part of the trunk will also make it appear quite old.

Preferably, bonsai should be grown outdoors under natural conditions. For display, these may be placed indoors for short periods only.

Earlier, growing bonsai was considered to be a hobby only for the rich. However, at present it is an art rather than a hobby. Bonsai have become popular with people residing in the 'concrete jungles' of the urban areas who have hardly any contact with nature. In Japan, in many families, the bonsai are handed down from generation to generation. A painter will keep aside his brush when the masterpiece is complete; a sculptor will give rest to his chisel once work is complete; but a bonsai-grower will never finish with his art piece. Bonsai is an art that is 'living' and ever-changing. From time to time, one may sit and watch it but cannot leave aside one's tools for good. A bonsai requires the watchful eye of its grower — some trimming here, some pruning there, mixing of soil today, repotting tomorrow, and the like.

This is an art form which has brought the East and West in the same forum — the culture of the east and the latest horticultural techniques of the west. The result is a beautiful creation.

16

Sleeping Seeds, Awake

A HIGH yield from any agricultural crop depends on a very important factor — the seed from which the crop is grown. These seeds (or the seed-like fruits such as cereals) should be pure, i.e. not mixed with any other unwanted seeds. The seeds should also have a high germination capacity and vigour, so that the seedlings produced are healthy and can combat diseases, insects, competition with weed seedlings, and unfavourable weather conditions.

To obtain healthy, pure, uninfected seeds with a high rate of germination, the stored seeds must be tested. There are many private, state and government seed testing laboratories.

The viability and longevity of stored seeds has been an interesting topic of study over a long period of time. Theophrastus (in Turner 1933) observed that some seeds have more vitality than others, and that at Cappadocia, in a place called Petra (Jordan), it is said that the seeds remain fertile and fit for sowing even after 40 years of storage. Most of these seeds are of established age as they are taken from the herbarium sheets or old cupboards.

What are seeds? The Angiosperms, or the Flowering Plants (with ca 250,000 species), can be distinguished from other lower groups of plants because of the presence of seeds. The seeds are usually produced as a result of pollination and fertilization. Generally they are enclosed in a dry or fleshy, dehiscent or indehiscent fruit.

In any flower the pistil comprises ovary, style and stigma — the ovary contains the ovules. After pollination and fertilization, the ovary becomes transformed into the fruit and the ovules within develop into seeds. A seed is the ripened ovule composed of an embryo, stored food (endosperm) and the seed-coat. A fruit in which the seed is borne, is the ripened ovary.

It has been observed that the seeds that are dry (and have their metabolic activities highly reduced) are capable of germination after prolonged storage. Seeds germinating after remaining buried in the soil for a number of years is something difficult to explain. It is also difficult to determine, with accuracy, the actual age of such seeds. Such reports are mostly based on the fact that these plants are uncommon in the areas they have been discovered — often on newly-excavated areas, on newly-ploughed soil, or in areas that have been under bomb-attack in a war.

Many experiments have been conducted, from time to time, on the viability of such seeds that have remained in the soil for prolonged periods. The oldest running 'seed–burial' trial is the one that was started by Dr Beal in USA. The seeds were buried in 1879 and were last tested in 1980 (Milberg 1990). The seeds of *Verbascum blattaria, V. thapsus* and *Malva pusilla* more than 100 years old, were viable.

The seeds of various weeds are of much interest and are often very difficult to eradicate. Turrill (1957) stated that studies taken up at Rothamsted (U.K.) concluded that, "Soil under pastures contained buried and viable seeds of weeds after periods of as much as 300 years in one area and only 30 to 40 years in others."

There are many reports on the life-span of seeds of various plants. Ewart (1908) in his article *On the Longevity of Seeds* mentions that the 'knowledge' about the longevity of seeds has much incorrect information, often contradictory and misleading. Of course, the study of this subject (when the article was written in 1908) was in infancy, and the 'knowledge' was fragmentary. On the basis of available data, Ewart (1908) divided all seeds into three groups according to their 'life-span under favourable conditions':

(i) 'Microbiotic seeds are short-lived, rarely more than three years;

(ii) 'Mesobiotic' seeds survive from three to fifteen years; and

(iii) 'Macrobiotic' seeds remain viable from 15 years to 100 years, or more.

De Candolle (1846) provided the earliest record of germination of old seeds, collected from the Botanical Garden of Florence, Italy, in 1831. About 17 species of these roughly 15-year-old seeds (out of 368 species in all) when planted in soil, germinated. The family Leguminosae showed the highest rate of germination (five out of 10 species that were tried).

Similar experiments have been conducted by many other workers. To name a few : Becquerel (1907) tried to germinate the seeds (25 to 136 years old) of 500 different species collected from the Museum of Natural History in Paris. The seeds of four families — Leguminosae, Nymphaeaceae, Malvaceae and Labiatae — showed good germination.

Schjelderup-Ebbe (1936) germinated the seeds that were approximately 34 to 112 years old. The oldest living seeds, according to his findings, were those of *Astragalus utriger* (82 years old).

Most interesting are, however, the reports on the germination of the seeds of *Nelumbo nucifera*, the Sacred Lotus of the Hindus. Exell (1931) reported that Robert Brown germinated the seeds of this plant in 1848. But there was some confusion about its nomenclature. The seeds were obtained from the Sloane Herbarium, British Museum, London. As reported (Barton 1985), the seeds germinated by Robert Brown were probably the seeds of *Nelumbo lutea* of North America, sent to Sloane Herbarium in 1727. Unfortunately, it has not been possible to calculate the correct age of the seeds from the British Museum.

After Robert Brown and a Japanese botanist, Ohga (1923), tested the *Nelumbo* seeds from the British Museum and was unsuccessful in germinating them. The viability of these seeds was lost sometime between 1855–1906. Ohga did not lose heart and tried to germinate the seeds of the plant (*Nelumbo nucifera*), collected from a layer of peat in a naturally-drained lake-bed in Manchuria. This time he was successful in germinating the seeds (1926a). Libby (1951) estimated the age of these seeds (from the Ohga collection) to be 1,040 ± 210 years, by using radio-carbon technique. These are, therefore, the oldest known viable seeds. These seeds from 'natural storage', however, did not germinate readily. They required some special treatment such as 'washing' with concentrated sulphuric acid or filing off a portion of the seed-coat.

Ohga (1926b) reports that seedlings from the 'treated old seeds' are more vigorous than those from the 'fresh seeds' of the same species. Normal plants from these seeds have been grown in many parts of the world.

Another interesting episode is that of the 'Egyptian Mummy Wheat'. There have been reports of germination of 'mummy wheat' and 'mummy pea' but they all appear to be a hoax. A report in

Gardener's Chronicle (Anon 1843) claimed that, "One of the twelve wheat seeds taken from an alabaster vase in a tomb that was not visited by man for 3,000 years had germinated. The plant grew to maturity and produced 27 seeds which germinated and produced vigorous plants." M.F. Tupper (in Barton 1985), who germinated (supposedly) the seeds, concluded: "If, and I see no reason to disbelieve it, this plant of wheat be indeed the product of a grain preserved since the time of the Pharaohs, we moderners may, within a little year, eat bread made of corn which Joseph might have reasonably thought to store in his granaries (!), and almost literally snatch a meal from the kneading-troughs of departing Israel" (Anon 1843).

However, there is no truth in all such stories. Luthra (1936) examined some seeds actually removed from ancient tombs. Although the grains retained their original shape, they were completely carbonized and, when moistened, they produced a 'black powdery mass'. Barton-Wright, Booth and Pringle (1944) analyzed some barley grains from King Tutankhamen's tomb. The grains were carbonized but the embryo and scutellum remained unaffected, and also there was loss of weight of these grains. Microchemical assay revealed the presence of riboflavin and nicotinic acid in them. According to these authors, the partial preservation of the grains was possible because of the oxygen-free atmosphere created by their own respiration and absorption of oxygen by other materials inside the tomb. No information is available about their germination.

Åberg (1950) described the morphological and taxonomical features of the barley and wheat grains (ca. 5,000 years old) collected from the Saqqara Pyramid in Egypt. An article (by an anonymous author) in *Nature* (1934) reports that with the invention of genuine 'mummy' wheat and barley grains and with the morphological studies and physiological tests of these grains, the popular belief about their germinability is no more valid.

The authenticity of such 'mummy' seeds is also questionable. Radiocarbon dating has put the genuine 'mummy' wheat and barley grains (from Egypt) to be 6,391 ± 180 years old (Libby 1951). It is, however, difficult to remove the already implanted belief about the germination of these grains from the public mind. More often than not, these grains may have been 'planted' inside the tombs, either accidentally or deliberately as a hoax.

There are many other similar reports which may not be correct. The often-mentioned age of the seeds of *Lupinus arcticus* (10,000 years) and of *Spergula arvensis* and *Chenopodium album* (1,800 years) are considered unreliable, whereas the archaeological datings of *Verbascum densiflorum* (850 years) and *V. thapsus* (660 years) are more convincing (Milberg 1990)

17

Threatened Plants

THE population explosion in the last few decades has increased developmental activities in various spheres. This has resulted in an imbalance of the natural ecosystems. Urbanization is one such activity. Coupled with various types of construction activities — such as dams, roads, buildings — it has directly affected the existing ecosystems. Mining operations, and stone quarries are other such activities, and all these together, result in depletion of natural resources. In addition, pollution due to urbanization, industrialization, use of chemical fertilizers, weedicides and pesticides, increase in the number of automobiles, increase in burning fossil fuel, have all contributed to the ecological imbalance. If the natural ecosystems fail to exist, its constituent elements — plants and animals — will also disappear.

During the Cretaceous Period (60 million years ago), the mighty Dinosaurs that roamed the earth's surface suddenly disappeared. Due to geological changes during this period, many other plants and animals also disappeared. But the extinction of the biological systems that is paving its way today, is due to modern man's activities leading to eco-imbalances in soil, water and air. Besides these, man has also indulged in activities like hunting, poaching and collecting which has paved a way to extinction of many biological species.

Fortunately, however, the situation is not so bleak today. Presently, there is a greater awareness on the need to conserve natural plant resources the world over. Some of the studies undertaken during the last four or five decades have highlighted that while there are some plants on the verge of extinction, some others have already become extinct. The International Union for Conservation of Nature and Natural Resources (IUCN) has estimated that ten per cent of the world's vascular plant species, i.e. about 20,000 to 25,000 species, are under varying degrees of threat. Consequently, IUCN have started the publication of Red Data Books on plants as well as animals, which include the information on threatened biological species.

Norman Myers, a noted conservationist, has emphasized that at least one species is disappearing each day in the tropical forests alone. If adequate steps are not taken immediately, in a few years' time there will be a species lost each hour. How serious the situation is, can be gauged from the statement of another conservationist, Peter H. Raven (formerly, Director, Missouri Botanical Garden, Missouri, USA): "A disappearing plant can take with it 10 to 30 dependent species, such as insects, higher animals and even other plants."

At the Tenth General Meeting of the IUCN, the Survival Commission reviewed the status of endangered species of plants and their habitats. The United States Endangered Species Act (1975), and the U.K. Wild Creatures and Wild Plants Act (1975), developments of various Conventions on conservation (Wetland Convention, World Heritage Convention, Endangered Species Convention, and South

Pacific Convention), setting up of the Biological Records Centre of the Nature Conservancy, UK and Threatened Plants Committee of the IUCN with regional and specialist groups on palms, orchids, cycads, tree-ferns and succulents have led to a world-wide awakening on the conservation, preservation and protection of the plants of the world. India also declared the Wild-Life (Protection) Act in 1972, but it did not include any plant species.

Apart from the Red Data Books published by IUCN, many such lists have been brought out by different institutions and persons, e.g. 'Smithsonian Report on Endangered and Threatened Plant Species of the United States' (Smithsonian Institute, Anonymous 1975), 'Rare and Endangered Species of Hawaiian Vascular Plants' (Fosberg and Herbst 1975), and 'List of Rare, Threatened and Endemic Plants for the Countries of Europe' (Lucas and Walters 1976).

IUCN recognizes different categories of rare and threatened plants.

1. **Endangered (E)**

   These taxa are in danger of extinction and their survival may not be possible if the causal factors are not removed.

   (a) *Ceropegia beddomei* Hook.f. (Asclepiadaceae) grows in open areas of the forest among bushes at an altitude of ± 1,000 metres. It is endemic to Kerala State in Peninsular India. It is endangered possibly because of habitat destruction.

   (b) *Rhododendron santapaui* Sastry et al. (Ericaceae) is a pretty epiphyte; a shrub with white starry flowers, has been collected only from Subansiri District in Arunachal Pradesh. It is endangered due to clearing of forests.

2. **Vulnerable (V)**

   "Taxa believed likely to move into the Endangered Category in the near future if the causal factors continue operating."

"Included are taxa of which most or all populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbances; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range."

(a) *Catamixis baccharoides* Thoms. (Asteraceae) is a sclerophyllous undershrub, endemic to the Siwalik belt and Tehri District of Garhwal, Himalayas in India. Causes for its decline are indiscriminate quarrying, mining and habitat destruction.

(b) *Cymbidium hookerianum* Reichb. f. (Orchidaceae) — The plants are robust with 60-120 cm long arching inflorescences bearing 10-20 large, fragrant flowers of long-lasting quality. An epiphyte or lithophyte, it occurs in the Himalayas from Kumaon eastwards up to Arunachal Pradesh at elevations of 1700-2500 m. Generally grows on large trees of *Quercus* in huge clumps. It can survive severe winter with snowfall, high humidity during summer months, and prefers moderate rainfall. In spite of all these reasons, the species is vulnerable because of over-exploitation and habitat destruction.

3. Rare (R)

"Taxa with small world populations that are not at present Endangered or Vulnerable but are at risk." "These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range".

(a) *Gentiana kurroo* Royle (Gentianaceae) is a herb with beautiful, large, purple-blue flowers from Western Himalayas. It is of rare occurrence. The plant is medicinally important and is, therefore, exploited for trade.

(b) *Gnetum ula* Brongn. (Gnetaceae) is an extensively woody climbing gymnosperm of botanical interest. Chiefly distributed in the Western Ghats; becoming rare due to large-scale clearing of forests.

4. Threatened (T)

Some species are marked as 'Threatened' where it is known that they are Endangered, Vulnerable or Rare, but there is not enough information to say which of the three categories is appropriate.

(a) *Aldrovanda vesiculosa* Linn. (Droseraceae) is an aquatic carnivorous plant of botanical interest. Reported from salt pans near Kolkata in West Bengal, it is threatened because its habitat near Kolkata (the Salt Lake Area) is being reclaimed. Recently, it has been reported from Manipur and Bangladesh.

(b) *Cyprepedium elegans* Reichb. F. (Orchidaceae) is a terrestrial herb with brownish, attractive flowers. Distributed in Lachen Valley, Sikkim and Eastern Tibet; it is threatened due to too much demand for trade.

5. Out of Danger (O)

These taxa were formerly included in one of the above categories, but now they are considered relatively secure because of effective conservation measures adopted, or the previous threat to their survival has been removed.

Rescued species are put into the 'Rare' category if the threat has been averted completely, or the 'Vulnerable' category if the species continues to be under threat.

6. **Indeterminate (I)**

   This category is operative when a species is known only from small areas (e.g. inbetween two mountains), where it has not been recorded for a long time but where the area has not been thoroughly surveyed.

7. **Insufficiently Known (K)**

   Taxa that are suspected but not definitely known to belong to any of the earlier-mentioned categories because of lack of enough information.

Extinction is a natural process. It is not that extinction is something abnormal taking place. As part of evolution, there will be extinction of the unfit and the survival of the fittest. But in the prevailing circumstances today, a species is not getting the complete evolutionary time span for survival. And that is why the rate of extinction has increased. To save these species various measures have been taken up:

(i) Botanical exploration of unexplored and underexplored regions of the country has been done and detailed floristic lists have been prepared — mainly by the Botanical Survey of India and other research institutions.

(ii) On the recommendation of the Botanical Survey of India and other concerned authorities, the Government of India has imposed restriction or completely banned the export of certain species such as *Aconitum* spp., *Colchicum luteum, Coptis teeta, Cycas beddomei. Dioscorea deltoidea, Dischidia rafflesiana, Gnetum scandens, Lycopodium phlegmaria, Meconopsis betonicifolia, Nardostachys grandiflora, Nepenthes khasiana,* all species of Orchids, *Podophyllum hexandrum, Pterocarpus santalinus, Rauvolfia densiflora, R. serpentina, R. tetraphylla, Rheum emodi and Santalum album.*

(iii) The custodians of flora and fauna have been entitled to check illegal trade practices.

(iv) Protection of habitats with natural vegetational cover is also one important step towards this goal.

(v) Important Botanical Gardens can help in acclimatization of plants growing under different ecological conditions and thus save the threatened plants.

(vi) The Government of Meghalaya has declared the *Nepenthes khasiana* habitats as protected areas, on the recommendation of the Botanical Survey of India.

It is a duty for all of us, particularly those who are dealing with plants (wild or cultivated) to inform the concerned authorities about any change in the population pattern. We may be able to notice certain plants which were growing wild near our habitat or locality, have dwindled in number or have disappeared completely. The concerned authorities can then look into the matter, do the required surveys in the complete geographical range of the plant, and do the needful to conserve it. Botanical Survey of India, and its Regional Offices in different parts of the country, International Union for Conservation of Nature and Natural Resources (IUCN), and its Threatened Plants Committee with regional and specialist groups on palms, orchids, cycads, tree-ferns and succulents, etc. have been able to increase conciousness among the people about the Conservation, Preservation and Protection of the flora of the world. We can also render help in doing this kind of work by providing information in our individual capacity.

Glossary of Technical Terms

Aerial roots	Common in orchids, are greenish and covered with a spongy tissue (velamen) with which they absorb atmospheric moisture.
Amalgamated	Combined into a single body.
Anther	Pollen-bearing part of a flower
Carpel	Innermost whorl of a flower; constitutes the female part and usually consists of an ovary, style and stigma.
Clinging roots	Roots of epiphytes that help in clinging to their support.
Conservatory	A greenhouse for growing and displaying rare and endangered plants.
Corolla	The second whorl of floral envelope comprising the petals — usually coloured and attractive.
Culm	The erect stem of grasses and bamboos, usually hollow except at the nodes.
Dormant	Appearing to be asleep or inactive.
Ecosystem	Inter-relationship between the living organisms and the physical environment forming a reasonably self-sufficient ecological unit in nature.
Elliptic	Oval in outline with narrowed to rounded ends and broad in the middle.
Embryo	Develops from the zygote within an ovule; the rudimentary plant in the seed.
Endosperm	The starch- or oil-containing tissue of many seeds; usually around the embryo.
Epiphyte	Certain plants which are perched on trees but do not derive any nourishment from them
Fissured	With long, narrow and deep openings, e.g. fissured bark.
Fossil fuel	Petroleum

Indigenous	Originating, living naturally in a particular region
Inflammation	Swelling.
Instigate	To initiate.
Lanceolate	(Leaf-shaped) lens-like
Lithophyte	Growing on barren rock or cliff, e g. some xerophytic lichens, certain orchids, etc
Mimicry	Resemblance of one organism to another that secures it an advantage such as protection from predation
Ovary	Ovule-bearing part of a pistil
Palmately-compound	Lobed or divided in a palmately or palmlike (or handlike) fashion; usually leaves
Panicle	An indeterminate and branched raceme with pedicellate flowers
Peat-bogs	Wet, poorly-drained areas containing partially carbonized vegetation of aquatic and semi-aquatic plants.
Perennial	A plant living for several years usually with new herbaceous growth each year.
Pinnate	Feather-formed, when leaflets are borne on two sides of the central rachis.
Placenta	The part of the ovary to which the ovules are attached
Pollination	Transfer of pollen grains from the dehiscing anther to the receptive stigma.
Precipitous (rock)	Dangerously steep or perpendicular.
Pseudobulb	The thickened stems of certain orchids, solid and borne above ground.
Receptacle	An enlarged or elongated end of the stem or floral axis which bears floral parts.
Rhizome	Underground stem as in ginger.
Rootstock	Subterranean stem.
Senility	Mental or physical weakness associated with old age.
Sclerophyllous	Plants with scale-like leaves.
Spike	Usually unbranched, elongated, simple, indeterminate inflorescence with sessile flowers
Spikelet	A secondary spike.

Stigma	:	The part of a plant's female reproductive organs (carpels) which is concerned with the reception of pollen.
Syconium		A special type of cup-like inflorescence with a narrow opening at the top, as seen in figs; male and female flowers (two types) are borne on the inner surface.
Trifoliate	:	A compound leaf with three leaflets.
Twig	:	A young leafy branch or stem.
Vascular plants	:	Plants in which vessels are present in the conducting tissues of the stele.
Velamen	:	The water-absorbing tissue around the aerial roots of epiphytic orchids.
Wart	,	Protuberance on the surface of the plant body.
Xeric	:	Dry climate with very little or no water in the soil as well as in the atmosphere.

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